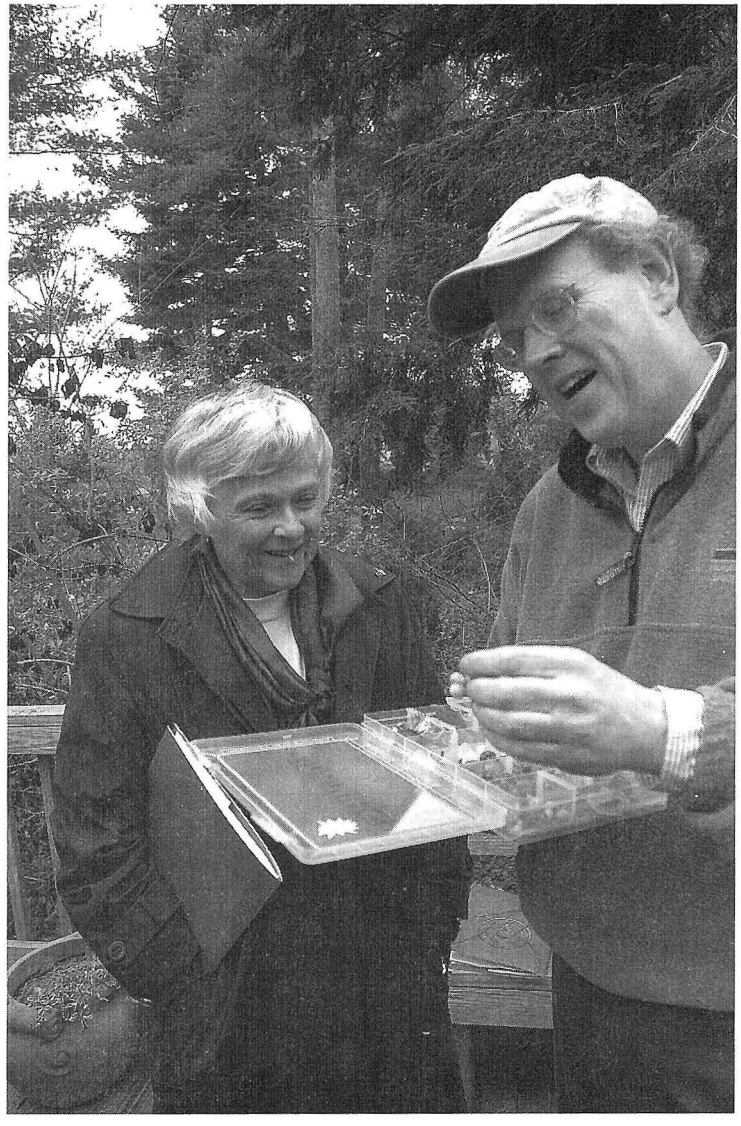
Ornamental Plants

Annual Reports and Research Reviews

2002



THE OHIO STATE UNIVERSITY OARDC

THE OHIO STATE UNIVERSITY EXTENSION

January 2003
Special Circular 189
Ohio Agricultural Research and Development Center
In Partnership With Ohio State University Extension

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Ornamental Plants
Annual Reports and Research Reviews
2002

Edited By

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Joseph F. Boggs
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Ohio Agricultural Research and Development Center
Ohio State University Extension
Department of Horticulture and Crop Science
The Ohio State University

January 2003
Special Circular 189
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Cover Photo:

Ohio State University President Karen A. Holbrook examines crabapple samples presented by James A. Chatfield, Northeast District Specialist and Assistant State Specialist, Horticulture. The samples are from crabapples growing in the University's Secrest Arboretum on the Wooster campus of the Ohio Agricultural Research and Development Center. A portion of the Arboretum appears behind Holbrook and Chatfield.

Salaries and research support were provided by state and federal funds appropriated to the Ohio Agricultural Research and Development Center and Ohio State University Extension of The Ohio State University's College of Food, Agricultural, and Environmental Sciences. Additional grant support was provided by the organizations and companies listed in the individual research and Extension reports.

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Ohio State University Extension Nursery, Landscape, and Turf Team Directory: 2003

Our Vision

The vision of the Extension Nursery, Landscape, and Turf Team is to serve as the University's partner with the green industry to position us for the future.

Our Mission

The mission of the Extension Nursery, Landscape, and Turf Team, through our interdisciplinary and industry partnerships, is to improve the process of acquisition, delivery, and support of accurate, practical, and timely educational resources.

An Invitation

Membership on the team is based on interest and commitment to the vision and the mission of the team. Potential members are encouraged to participate in some of our activities to determine if they would like to become a part of our team. If you are interested in the work of the team, please contact any of the team members.

The ENLT Team greatly appreciates the significant funding support of the Ohio Nursery and Landscape Association.

Team Members

Betsy Anderson

- Ornamental plant pecticide research (IR-4 Program)
- Biological pest control
- Identification of nursery, greenhouse, and landscape pesticide needs
- Registration of new pesticide products

Biological Science Technician, USDA-ARS
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- Weed identification
- Insect identification
- Greenhouse management
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- IPM

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- Landscape ornamentals
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- Communications
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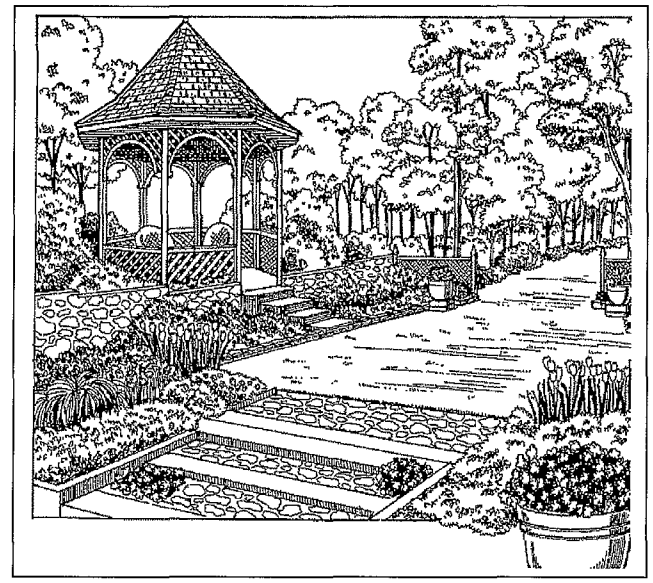

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- Plant establishment

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- Greenhouse management
- Fruit production

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During the growing season, the team teleconferences weekly and develops a newsletter called the *Buckeye Yard and Garden Line,* which is available by a fax subscription service (contact a local team member) or on the World-Wide Web at:

http://www.hcs.ohio-state.edu/hcs/hcs.html

(Ohio State University Department of Horticulture and Crop Science, *Horticulture and Crop Science in Virtual Perspective)*

***Buckeye Yard and Garden Line* Fax Centers**

Clark County	Pam Bennett
Clermont County	Gary Gao
Cuyahoga County	Tim Malinich
Franklin County	Jane Martin
Hamilton County	Joe Boggs
Lake County	Randy Zondag
Lucas County	Amy Stone
Montgomery County	Pete Lane
Putnam County	Glen Arnold

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Floriculture Industry Roundtable of Ohio: 2003

Financially supported by the Ohio Floriculture Foundation.

Our Mission

The mission of the Floriculture Roundtable of Ohio is to provide an educational forum to floriculture Extension personnel, growers, and members of the allied industries across the Midwestern region, currently including Ohio, Michigan, Pennsylvania, Kentucky, and Indiana, for the exchange, discussion, and dissemination of information related to floriculture.

Serving You

Do you ever have problems with crops? The Roundtable offers you free assistance in finding solutions. All persons listed in this directory are just a phone call away. Take advantage of the opportunity!

Greenhouse Management

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Everett, Craig
Gao, Gary
Kneen, Hal
Krauskopf, Dean
McMahon, Peg
McMahon, Robert W. (Bob)
Metzger, Jim
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Hoitink, Harry
Nameth, Steve
Taylor, Nancy

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Cloyd, Raymond
McMahon, Robert W. (Bob)

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Ling, Peter
Short, Ted

Management and Economics

Kneen, Hal
Rhodus, Tim

Composting

Hoitink, Harry

Crop Physiology

Carver, Steve
Jones, Michelle
McMahon, Peg
Metzger, Jim
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- Compatibility of pest control materials with natural enemies
- Test efficacy of new pest control materials

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- Marketing

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330-262-7634

- IPM
- Control of insect pests of floriculture crops with natural enemies and use of hot-water drenches and sprays, and manipulation of plant height by environmental manipulation (water and temperature)
- Greenhouse production and management

Metzger, James (Jim)

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- Role of hormones in plant growth and development
- Environmental control of flowering
- Use of biotechnology to improve floricultural crops

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- Diseases of floral crops: identification, control, and management
- Identification and characterization of viruses of floral crops

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- Modeling and timing of floricultural crops
- Water quality and nutrition of floricultural crops

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- Multimedia applications for marketing and education

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- Evapotranspiration of greenhouse crops
- Solar energy systems
- Mechanization of horticultural crops
- Natural ventilation of greenhouses

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- Diagnosis of plant diseases, all crops

Watson, Maurice

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- Water quality, composting, and environmental pollution problems

Floriculture Industry Roundtable of Ohio Activities Include:

- Assisting growers with crop production problems.
- Holding biweekly conference calls to assess the state of the industry. These calls are used as an educational forum by Roundtable members. Grower participation in the biweekly phone calls is possible (and encouraged) on a port-available basis by contacting Charles Behnke at 440-326-5859 prior to the biweekly conference.
- Preparing and faxing out informational alerts (FIROOFAX) to industry members when emergencies arise.
- Collaborating with the Ohio Florists Association and other regional grower associations in the organization of educational seminars and workshops.

Do not hesitate to get in touch with any of the Roundtable members listed in this Directory if you have any floricultural problem or wish to share information.

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Ohio State University Extension 2002 *Buckeye Yard and Garden Line* Evaluation Survey

Amy K. Stone and James A. Chatfield

Summary

One hundred fifty-five respondents completed and returned the 2002 *Buckeye Yard and Garden Line* (*BYGL*) Survey. Of the survey respondents, 69% agreed that *BYGL* was useful to their job and business.

The individuals who responded to the survey indicated that *BYGL* had an estimated economic impact of more than $200,750. This is a significant under-representation of the economic impact since no attempt was made to translate the reported impact to the overall *BYGL* audience.

Information from *BYGL* is then further disseminated from their subscriptions to more than 800,000 additional persons through radio programs, newspaper columns and articles, Master Gardener volunteers, students, and green-industry employees.

Introduction

The *Buckeye Yard and Garden Line* (*BYGL*) is one of the key ways through which Ohio State University Extension and the Extension Nursery Landscape and Turf (ENLT) Team provide ornamental plant and plant problem information to the green industry, Extension offices, and the general public. This article answers some questions about *BYGL* and provides the results of the 2002 *BYGL* Evaluation Survey.

Amy K. Stone, Ohio State University Extension, Lucas County; and James A. Chatfield, Ohio State University Extension, Northeast District/Department of Horticulture and Crop Science.

What Is *BYGL?*

The *Buckeye Yard and Garden Line (BYGL)* is a weekly horticultural update in the form of a horticultural related newsletter. It is written by OSU Extension agents and specialists, from a conference call held every Tuesday from April to October. *BYGL* is funded by the Ohio Nursery and Landscape Association (ONLA) and OSU Extension, with additional contributions from the Ohio Chapter of the International Society of Arboriculture (Ohio-ISA).

Who Is *BYGL's* Audience?

BYGL is written for green industry professionals, Extension agents, Master Gardener volunteers, and other horticulturists in Ohio and throughout the United States, especially the Midwest.

Some of those receiving BYGL are members of the following:

ONLA; ISA; Ohio Turfgrass Foundation (OTF); Ohio Florists Association (OFA); Society of Municipal Arborists; Perennial Plant Association; Garden Writers Association of America; Ohio Lawn Care Association (OLCA); Ohio Landscape Association (OLA); Ohio Farm Bureau; International Or-

namental Crabapple Association; and Ohio Fruit and Vegetable Association.

How Do You Receive *BYGL?*

There are three ways to receive *BYGL* — by e-mail, by fax subscription, and by going directly on the World Wide Web. Here's how:

- By e-mail: Simply send your e-mail address to Jim Chatfield:

  chatfield.1@osu.edu

- On the World Wide Web: Access *Buckeye Yard and Garden onLine* on Ohio State University's *Horticulture and Crop Science in Virtual Perspective*

  http://bygl.osu.edu/

- For fax newsletter subscriptions, contact one of these Ohio State University Extension offices:

Clark County	
Pam Bennett	937-328-4607
Clermont County	
Gary Gao	513-732-7070
Cuyahoga County	
Jack Kerrigan	216-397-6000
Franklin County	
Jane Martin	614-462-6700
Hamilton County	
Joe Boggs	513-946-8993
Lake County	
Randy Zondag	440-350-2269
Lucas County	
Amy Stone	419-578-6783 ext 12
Montgomery County	
Pete Lane	937-224-9654
Putnam County	
Glen Arnold	419-523-6294

Is There a Cost for *BYGL?*

Fax subscriptions have a $40 fee to cover phone line costs. If you are a member of the Ohio Nursery and Landscape Association (ONLA), the Ohio Chapter of the International Society of Arboriculture (ISA), or the Ohio Turfgrass Foundation (OTF), this fee is waived as part of your membership benefits.

Where Can You Find the Time for *BYGL?*

Reading time during the growing season comes at a premium, and that is why *BYGL* is formatted in short bytes — one to two paragraphs — of the most relevant information on a particular topic. We also strive for a lively, user-friendly, and humorous style.

What Is *Buckeye Yard and Garden onLine?*

This is the World Wide Web version of *BYGL*, and it comes not only with the text of *BYGL* available, but also with hot links to color images of pests and plants referenced in the *BYGL* and to more than 60,000 additional fact sheets from Ohio State University and other universities.

What Is *BYGLive!?*

BYGLive! is a series of informal programs held at arboreta throughout Ohio. The participants have a chance to see plants and plant and pest development throughout the season, to do some diagnostic troubleshooting, and to provide observations and insights that will add to the *BYGL*.

Sites and key contacts for these programs for 2003 are:

- Cincinnati at Spring Grove Arboretum
  Joe Boggs
  513-946-8993

- Toledo at Stranahan Arboretum and Toledo Botanical Garden
  Amy Stone
  419-578-6783
- Akron at Seiberling Naturealm
  Denise Ellsworth
  330-497-1161

Survey Results

Total Number of Returns: 155

I. General Background Questions

A. What is your primary type of business, operation, or profession?

Number of Commercial or For-Profit Companies: 76

(nursery; greenhouse; golf course; lawn care service; contract landscape maintenance; tree care/arborist; garden center; industrial or office park/plant; landscape architect/designer; or supplier/dealer)

Number of Non-Profit Companies: 61

(Extension; park; school, college, or university; museum; cemetery/memorial garden; or government facility)

Non Professional: 18

(home gardener or Extension Master Gardener)

B. Are you a member of the following? (Please select all that apply.)

Ohio Nursery and Landscape Association: 74

International Society of Arboriculture: 36

Ohio Turfgrass Foundation: 21

Ohio Florists Association: 19

C. How do you receive the *BYGL*?

E-mail:	94
Fax:	57
Web:	4

It should be noted that the BYGL Evaluation Survey is not sent out on the Web, but only to the e-mail listserve.

D. Do you share the *BYGL* with others?

Yes:	128
No:	22

II. *BYGL* Impact and Usefulness

A. How strongly do you agree with each of the following statements? Please write down the most appropriate response.

SA	=	Strongly Agree
A	=	Agree
N	=	Neutral
D	=	Disagree
SD	=	Strongly Disagree
NA	=	Not Applicable

1. *BYGL* was useful to my job and business:

SA	=	72
A	=	32
N	=	31
D	=	0
SD	=	0
NA	=	15

2. *BYGL* helped in answering client/customer questions:

SA	=	61
A	=	31
N	=	35
D	=	0
SD	=	0
NA	=	15

3. I (we) changed some horticultural practices based on information in *BYGL*.

SA	=	42
A	=	56

N = 36
D = 0
SD = 0
NA = 14

4. I (we) changed some pest management practices based on information in *BYGL*.

SA = 48
A = 53
N = 27
D = 13
SD = 0
NA = 14

5. *BYGL* has resulted in improved customer service in our company or business.

SA = 51
A = 49
N = 16
D = 9
SD = 0
NA = 17

B. What have you learned from *BYGL* this season? Please fill in the blank following each statement.

1. Number of new insects learned: 410
2. Number of new diseases learned: 373
3. Number of new cultural (non-insect, non-disease) problems learned: 353
4. Number of times pesticide use was improved: 424

C. Has the information in *BYGL* saved your company money or increased your profit?

Yes: 74
No: 29

1. If you answered "yes" to question C, please select a range.

   Of the people who responded to our survey, we estimate that *BYGL* has had an economic impact of $200,750. It should be noted that this is a significant under-representation of the economic impact since we did not attempt to translate the reported impact to the overall *BYGL* audience.

2. If you answered "yes" to question C, please check all that apply. This information will only be used for reporting the economic impacts of *BYGL*.

   Time savings to you and your operation: 42

   Reduction of pesticide usage: 42

   Proper selection of plant material: 38

   Proper selection of pesticides: 48

   Improved customer service: 43

D. Although the length of BYGL does vary from week to week, depending upon the amount of information to be discussed, what would be an ideal range of pages per issue?

Under 6: 45
6 to 8: 36
8 to 10: 12
10 to 12: 11
No limit, as long as the information is important: 52

Selected Comments

BYGL is very much appreciated by myself, employees, and customers. More than once this summer I was able to hand a copy of the BYGL article to a customer that just handed me a stem, leaf, or plastic bag full of bugs, and was able to solve their problems and back it up with your technical advice. The most satisfying times were when I needed help convincing them that it was not necessary to spray anything. Keep up the good work.

— Pat Kaufman, Deeter Nurseries, Inc.

BYGL is our bible when it comes to writing articles for the newspaper, as well as keeping up on the horticultural happenings for the hotline. Thank you!

— Laura McConnell
and the Union County Master Gardeners
Marysville, Ohio

BYGL is . . .

No. 1. Saving the environment with information on proper pesticides used at the correct time.

No. 2. Giving my business an edge when educating my customers.

No. 3. Helping provide my customers with long-term results by using proper cultural practices.

— Melanie White
Alliance, Ohio

Very informative; a great tool for training employees.

— Lori Spurlock, Scarff's Garden Center

A tremendous time saver by alerting us to what is going on in the landscape, as well as why, and what should be done (if anything). It also helps provide us with some credibility if we happen to tell a customer something they don't want to hear. BYGL has become an invaluable resource to the green industry.

— Paul Mendezoff, Petitti Garden Center
Strongsville, Ohio

BYGL serves as a great resource and a way to stay connected with Ohio State University Extension.

— Sandy Farber, University of D.C.
Washington, D.C.

The newsletter is a very valuable tool in providing up-to-date information for us to pass on to others.

— Richard Sorg, Muskingum SWCD
Zanesville, Ohio

Educational, entertaining, humorous, friendly, on-target, timely, and just plain helpful. Thanks for sharing your expertise.

— Nancy Jackson, Warren County

BYGL is a wonderful source for news that is applicable to our area, as well as across the state. You become aware of the talented people that work with this program and their willingness to help with any and all problems. This is some of the best tax dollar expenditure and hopefully those in the state house will realize that. Environmental issues are becoming increasingly important.

— Joyce Lane, OSU Extension
Master Gardener

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Weather, Environmental, and Cultural Problems of Ornamental Plants in Ohio: 2002

Pamela J. Bennett

Introduction

This report includes a compilation of Ohio weather conditions and noteworthy environmentally induced and cultural plant problems in 2002. Observations were drawn from Ohio State University Extension's *Buckeye Yard and Garden Line*, the Ohio Department of Natural Resources *Monthly Water Inventory Report*, and the State Climatologist's Office for Ohio.

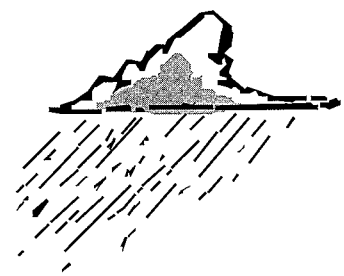
Discussion

Weather Background

This section discusses precipitation and temperature reports for the season. At the end of the section are tables showing statewide precipitation from January through September and average temperatures and departures from normal for three locations in the state for April through September 2002.

Precipitation for the 2002 calendar year started off rather dry across most of the state except for northwestern and south-central Ohio, which had slightly above normal amounts. However, in March, April, and May, precipitation was noticeably above normal. In March, precipitation fell as rain and snow. In southern Ohio, more than 6" of rain was reported in several locations. On March 26, snow and freezing rain fell in the northern half of the state with anywhere from 5 to 10" of snow reported.

April brought more rain and was the 15th wettest April during the past 107 years of records. It was the 10th wettest for the southeastern region, the 11th wettest for the central hills region, and the 13th wettest for the southwestern region.



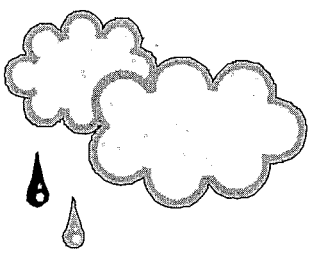
Several significant storms occurred during the month, with the most notable storm on April 12 in the western part of Ohio. Southern Ohio received 3" of rain during this storm. Additional storms occurred on April 27 and 28, with a tornado touching down in Stark County causing considerable damage on the 28th.

Extension agents in Columbus and Cincinnati reported temperatures 20 degrees above normal with 85ºF and 84ºF on April 15. However, temperatures in the following week were back in the 40ºF range.

Pamela J. Bennett, Ohio State University Extension, Clark County.

Precipitation for May was also above normal statewide except for scattered areas in northwestern Ohio where it was below normal. This was the 7th wettest May during the past 107 years of record for the northeastern region, and the 8th wettest for the southwestern region. Cheviot, in Hamilton County, reported the greatest amount of precipitation with 9.43". Precipitation fell every week during May with minor flooding occurring in areas with already saturated soils.

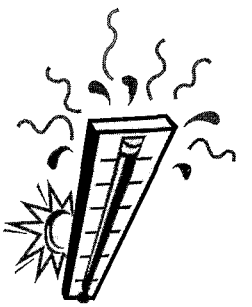
The average statewide precipitation for the year to date was 4.09" above normal. Temperatures were below normal the first of the month and remained wet and cool, according to Extension agents; planting was delayed in many areas of the state. Cleveland reported the 7th coldest May on record. On May 19, Columbus had a record low of 34ºF, and Cincinnati had a record low of 30ºF. Scattered frosts occurred across much of the state during the third week of May.



In June, precipitation was generally below normal in the northwestern half of the state and above normal in the southeastern region. June ended up being the 10th driest for the northwestern region and the 17th driest for the northeastern region during the past 107 years of record. The central region of the state was in an incipient drought, according to the Palmer Drought Severity Index (PDSI), while the rest of the state was near normal.

Temperatures in early June remained below normal but changed drastically near the end of the month. Extension agents reported a quick transition from spring-like to summer-like conditions, with temperatures in the high 80s and low 90s. Due to the lack of precipitation at the end of the month along with high temperatures, agents were reporting cracks in soil and decline of annuals and perennials due to poor root system development.

Precipitation in July was noticeably below normal across much of the state. For the entire state, this was the 16th driest July during the past 107 years. The first half of the month was drier than the second half. In some areas, less than 0.5" of rain fell during scattered thunderstorms on July 9 and 10. However, southeastern Ohio did receive around 1 to 3" of rain during these storms.



In addition to being dry, temperatures averaged above normal across the state. Extension agents noted that soils were cracked and as hard as cement. In the Toledo area, there are 14 days over 90ºF during an average year; by early July, there had already been 12 days over 90ºF.

August precipitation was also noticeably below normal across most of the state, making this the 19th driest August in the past 107 years. Precipitation was spotty with no widespread rains occurring during the entire month. In general, northern Ohio had the greatest amount of precipitation during August. Some stations reported only 1 or 2 days of rain during the entire month. All 10 reporting stations in Ohio noted a moderate to severe drought, according to the PDSI. Precipitation still remained above normal for most of the state for the 2002 year through

Table 1. 2002 Statewide Precipitation January through September.

Month	Average Inches Precipitation	Percent of Normal
January	2.05	80
February	1.72	76
March	3.72	117
April	4.72	132
May	5.16	132
June	3.51	91
July	2.61	64
August	2.17	63
September	4.11	139

Source: Data from Ohio Department of Natural Resources, Monthly Water Inventory Reports.

Table 2. Average Temperatures and Departures from Normal, January through September 2002, for Cleveland, Columbus, and Cincinnati.

	Cleveland		Columbus		Cincinnati	
Month	Avg. Temp. Fº	Departure Fº	Avg. Temp. Fº	Departure Fº	Avg. Temp. Fº	Departure Fº
April	50.5	2.9	54.6	2.6	55.7	2.0
May	55.5	-3.0	58.8	-2.8	59.6	-4.1
June	70.4	2.9	73.5	2.3	72.9	0.9
July	75.5	3.6	77.9	2.8	78.2	1.9
August	73.6	3.4	76.2	2.7	77.5	3.0
September	68.7	5.4	70.0	4.2	71.6	4.2

Source: Average temperature is an average of all high and low temperatures recorded daily for the given location. Data for Cleveland were taken from: **www.csuohio.edu/nws/climate/cle/climatecle.html.** Data for Columbus and Cincinnati were take from: **www.nws.noaa.gov/er/iln/lcdpage.htm.**

Table 3. Number of Days 90ºF or Above, June through September 2002, for Cleveland, Columbus, and Cincinnati.

Location	June	July	August	September	Season Total
Cleveland	3	10	4	4	21
Columbus	2	13	9	6	30
Cincinnati	2	16	12	7	37

August. The Cincinnati area had 25 days of temperatures above 90ºF by mid-August.

September precipitation was above normal across most of the state, bringing relief to many areas. However, the northwestern region was still below normal for September. Many areas of the state received little or no rain during the first half of the month. This, combined with above-normal temperatures, worsened the drought-like conditions that were prevalent during the summer.

When it did rain, areas of the state received quite a bit. Montgomery and Clark Counties experienced the 8th wettest September with 8.41" and 8.31" respectively. Effects of Hurricane Isidore moved through the state on September 26 and resulted in moderate to heavy rain with approximately 1 to 2" in the northern half and 2 to 3" in the southern half of Ohio. Southwestern and central Ohio received more than 5".

Above normal temperatures occurred during the first part of the month. On the 8th, Springfield set a record with 95ºF and on the 9th Toledo set a record with 95ºF. Columbus had six days of over 90ºF temperatures before the 10th of the month. Towards the third week, temperatures returned to normal.

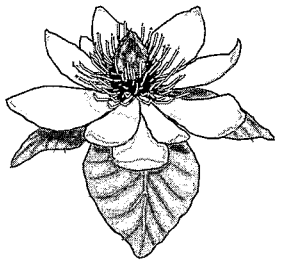
Useful websites for weather-related topics are listed here:

Ohio Department of Natural Resources, Division of Water, monthly water inventory report: **http://www.dnr.state.oh.us/water/**

National Oceanic and Atmosphere Administration (NPOAA), drought report: **http://www.drought.noaa.gov/**

USDA Topsoil Moisture Chart: **http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/topsoil.html**

Degree day, phenology update for Ohio: **http://www.oardc.ohio-state.edu/gdd**



Environmental Effects on Ornamental Plants

Reports of winter injury were few this past growing season. There were numerous reports, however, of deciduous plant material blooming out of season. Sporadic late summer and fall blooms were reported on magnolia, royal paulownia, Callery pears, crabapples, rhododendrons, azaleas, and viburnums. Speculation was that summer drought conditions had induced this unusual bloom period.

There were, however, reports of plant problems due to the cold, wet, prolonged spring followed by several days of extremely warm weather. Hostas exhibited leaf scorch; 2" to 4" caliper maples were in the wilt stage; and yews were reported to have new growth turn brown and others completely died. In most cases, these plants had other variables associated with the problems, such as improper planting and mulching or being newly established; the weather, however, exacerbated the situation.

Irrigation was also an issue this past growing season. There were numerous questions regarding proper watering techniques. Thorough, deep watering was recommended. Established trees and shrubs can go longer periods without water depending upon the extent and depth of their root systems.

Young plants, either newly planted or planted within the last few years, require more water. A young tree up to 2.5" caliper requires about 5 gallons of water every 7 to 10 days to survive. Larger trees, 3 to 4" caliper, need about 10 gallons per tree every 7

to 10 days. It is quite difficult to water large, established trees; however, if they begin to show wilting, begin to change color prematurely, or if the margin of the leaves begins to turn brown (leaf scorch), apply 2" of water beneath the crown of the tree.

In addition, *BYGL* readers were reminded that drought-stressed plants were subject to greater risks of insect borer attacks. Most plant cells fully engorged with water, or turgid, have a defense mechanism to protect themselves from many borer pests.

Cultural Problems on Ornamental Plants

Planting Depth

Tree planting issues continue to remain in the forefront on *BYGL* conference calls. There were several reports regarding trees planted with the root flare well below the soil surface, or soil being added to the surface of established root systems.

When preparing the depth of the hole, first check for evidence of flaring buttress roots. This may mean that soil should be removed to determine the location of the root flare. Plant trees at the level of the exposed buttress roots or the root flare. In some cases, trees are planted so that the root flare is slightly above ground level.

In relation to planting depth, the issue of adding soil on top of the root system of trees was discussed. Gardeners have the tendency to want to design flowerbeds under trees; they sometimes accomplish this by adding soil around the base of the tree, adding more soil over the root system of the trees.

Planting trees too deep and/or adding soil to existing grades of trees leads to reduced oxygen levels for tree roots. Roots suffer from the lack of oxygen, leading to branch dieback. This may occur over a period of time, depending on the overall health of the tree. The extent of the injury depends on many variables, including species, age, and condition of the tree; the depth and the type of fill; drainage; and subsequent exposure to insect and disease pressures.

References

1. Hartman, J. R., Pirone, T. P., and Sall, M. A. *Pirone's Tree Maintenance.* 2000. Oxford University Press.

2. Dr. Jeffery Rogers, State Climatologist, with the State Climatologist's Office for Ohio, provides current and archived weather information for several locations in the state. This information is available at: **http://www.geography.ohio-state.edu/faculty/rogers/statclim.html**

3. The *Buckeye Yard and Garden onLine* is available at **bygl.osu.edu**

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Infectious Disease Problems of Ornamental Plants in Ohio: 2002

James A. Chatfield, Nancy A. Taylor, Erik A. Draper, and Joseph F. Boggs

Introduction

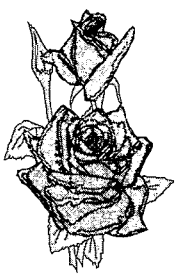
Disease summaries for 2002 were derived from the OSU Extension *Buckeye Yard and Garden Line (BYGL)* electronic newsletter, reports from the C. Wayne Ellett Plant and Pest Diagnostic Clinic (PPDC), and other reports. As always, environmental conditions unique to the particular growing season played a big part in the profile of diseases for 2002.

The profile for much of Ohio in 2002 was a very wet spring, which got anthracnose diseases and apple scab (which love wet weather on emerging and new foliage) off to a good start, followed by a very dry summer and normal to excessive fall precipitation. A few of the disease profiles and disease control perspectives from 2002 are noted here.

First, though, here is a reminder of one of the basics of plant disease management.

Horticulturalist, Cleanse Thyself

Sanitation practices are an essential part of good horticulture when it comes to disease management. How so? Let us count a few ways.



1. The obvious example is a disease like **rose black spot.** The fungus makes it from one year to the next (overwintering) on black-spotted leaves, canes, and other plant parts. So cleaning up diseased plant tissue at the end of the season, in the fall, or before the next one starts the following spring, helps control the disease.

Of course, this sanitation effort is not a complete control. Microscopic spores may blow in from other people's roses to infect your crop, and preventive fungicides may be needed, but sanitation helps limit disease significantly.

Since the rose black spot fungus also has repeating cycles of spore production during the growing season, it is also important to clean up spotted leaves to the extent possible. Get them off the plants if they become infected to reduce the amount of new infections as the season progresses.

2. Sometimes the effects of good sanitation are less obvious. One example is the relationship on crabapple of the diseases **frogeye leafspot, black rot,** and **fireblight.** Frogeye leaf spot and black rot (which cause branch cankers and dieback on crabapple) are caused by the same *Botryosphaeria* fun-

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gus. This "Bot rot" fungus is sometimes termed an "opportunistic" pathogen on stem tissue, meaning that it is best at colonizing already declining, dying, or dead stems. Here is where fireblight comes into the picture.

Fireblight is caused by a bacterium that causes blossom, leaf, and stem tissue to die back. Guess what? After this stem tissue dies (leaving dead shoots with characteristic "shepherd's crook" symptoms), this stem tissue often becomes colonized by the opportunistic *Botryosphaeria* fungus.

And if these fire-blighted shoots are left on the plant, not only do the fireblight bacteria overwinter and provide bacteria to infect other blossoms and shoots the next season, but also the black-rotted stem tissue provides spores that cause much more than usual frogeye leaf spot the next year. You can see it clearly, as the leaves next to the fireblight strikes have many more leaf spots (infections) than the other foliage on the tree.

3. Sanitation is critical at all levels of horticulture, from **orange rust** on brambles which is so hard to control with fungicides that the best approach is to simply remove (rogue out) all of the affected brambles (both cultivated and wild), to **late blight of potato** (a big contributor to the Irish potato famine), in which potato farmers soon learned that the fungus survived from year to year in cull piles of black-rotted potatoes that were left behind in the fields.

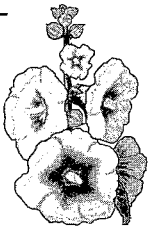
In fact, one of the pithiest plant pathological sayings from around the turn of the century (from the 19th to the 20th Century) was about sanitation, when Antonin Woronin intoned: "The only cure for cabbage hernia is fire!" Say what? To decode: cabbage hernia is the old name for what we now call **club root of cabbage,** a serious disease — and the only control at that time was to burn the crop residue with its infested leaves, depriving the pathogen of a place to survive over the winter. They went after the pathogen where it lived.

So, if you see **crown gall growths** on stems of the rose or euonymus you are about to purchase — don't! If **Botrytis gray mold** develops on geranium flowers — deadhead. Remember, when planting, it is: Location. Location. Location. For plant health maintenance, it is often: Sanitation. Sanitation. Sanitation.

Now, lets turn to some profiles of a few of the diseases noted in 2002.

Hollyhock Rust

This fungal disease causes orangish, waxy, rust pustules on the underside of leaves and bright orange spots with red centers on the upper surface of leaves and on shoots of hollyhocks *(Alcea rosea)* and certain other relatives in the mallow family (Malvaceae). Eventually, the rust pustules on the underside turn a reddish to chocolate brown color, and when disease is severe, considerable leaf drop may occur.



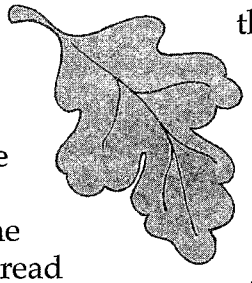
The primary key to control is sanitation (there's that word again!) in its many forms. That means removing all infested plant parts, leaves, and stems at the end of the season. This helps limit the amount of overwintering fungus that will survive in your garden from year to year.

It is also important to remove any leaves that become infected during the growing season, because this fungus *(Puccinia malvacearum)* has a repeating stage that just goes on and on and on, producing new rust spores to continue causing new infections on your (and your neighbor's) hollyhocks. Finally, another means of sanitation includes weeding out the round-leaved mallows *(Malva rotundifolia)* from your garden since this plant is also a host for this rust fungus.

In addition to sanitation, keeping water off the foliage to the extent possible and providing good air movement where the hollyhocks grow are important to help limit hollyhock rust development.

As to fungicide controls of hollyhock rust, products containing chlorothalonil, mancozeb, and sulfur can help, but infections start in spring and continue during rainy weather all the way into the fall. Therefore, numerous applications at 10- to 14-day intervals may be necessary to completely prevent rust from developing. This is why proper sanitation is so critical. Unfortunately, hollyhock varieties resistant to hollyhock rust are not available.

Oak Wilt



Oak wilt, caused by the fungus *Ceratocystis fagacearum*, is a lethal disease of oaks. The disease interferes with water uptake and causes a wilting syndrome which often results in death of the tree. The fungal pathogen can spread from infected trees to healthy trees by two routes.

One route occurs between neighboring trees by way of root grafts. These root grafts develop when roots from two different trees grow together and bond to one another. The tissues of the roots at these junctions become a bridge through which the oak wilt fungus can pass from one tree to the next tree.

The other route for oak wilt spread occurs above ground and involves an insect vector. There is a high risk of overland spread of oak wilt disease to healthy oak trees when the trees are wounded during the warm season months. This wounding can occur by pruning or storm damage and subsequent repair.

The greatest risk period for oak wilt spread is during the months of April, May, and June. It's during this time that picnic or sap beetles, the insects considered to be the primary vector of oak wilt disease, are most likely to be carrying spores of the fungus. These beetles are attracted to sap flows from freshly wounded trees.

Thus, it is important NOT to cause any unnecessary wounds to oaks during the high-risk period of April 15 through July 1.

A more conservative approach to preventing overland spread of oak wilt is to avoid wounding oak trees throughout the growing season (April 15 to October 1). The exception to this recommendation is the need to repair oaks after storm damage occurs. In this case, it is recommended that wounds produced during storm damage repair be treated with a latex paint to reduce the attractiveness of the wound to picnic beetles.

For more information on oak wilt disease and descriptions and pictures of symptoms, refer to OSU Extension Fact Sheet No. HYG-3306-01, *Oak Wilt*, for details.

Diagnosing Conifer Diseases

Nancy Taylor, director of the Ohio State University C. Wayne Ellett Plant and Pest Diagnostic Clinic, reminds sample senders that when you send pine and spruce samples to the clinic to check for needle diseases, please keep a couple of sample pointers in mind.

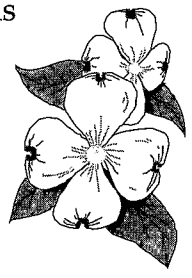
You should include not only branches with the discolored needles attached, but also a bag of fallen needles collected from branch crotches (rather than from the ground). This is because many needle diseases involve fungal infections of last season's needles. Examples include *Rhizosphaera* on spruce, *Dothistroma* on Austrian pine, and *Lophodermium* and *Cycloneusma* on Scots pine. Needles just starting to show symptoms are often quite difficult or impossible to diagnose properly.

Why does all this matter — isn't a needle disease by any other name just a needle disease? No! Control recommendations may differ significantly. For example, on Scots pine, protectant fungicides for Cycloneusma needlecast should be applied to prevent infections in spring, but for Lophodermium needlecast, fungicides should be applied to prevent infections in late summer.

So, the correct diagnosis of which disease is on your pines is critical and to do this properly, collect older, fallen needles that have not yet dropped to the ground.

Powdery Mildews

Many plants are affected by powdery mildew diseases. The most familiar way to recognize powdery mildew diseases is the actual sign of the powdery mildew fungus growing on the upper leaf surface. We are all familiar with these tell-tale powdery white fungal mycelial threads, and if you are Clark Kent, you can see the microscopic chains of spores growing from this mycelia. Less familiar are the symptoms of reddening and/or bronzing of leaf tissue on dogwood, magnolia, and rose and distortion of new growth on planetrees, dogwood, and rose that accompany these diseases.



Control involves improving air movement, to the extent possible, with judicious pruning and plant siting and use of powdery-mildew-resistant varieties when available. Also recognize that in many cases the disease causes little harm to plant health, and fungicides may be used when necessary.

Common powdery mildew fungicides include triforine (e.g., Funginex), thiophanate-methyl (e.g., Cleary's 3336), and propiconazole (e.g., Banner). Read and follow the fungicide label carefully when applying to a particular plant.

Downy Mildew on Cranberrybush Viburnum

In many years, this disease is first seen by early July and intensifies in August and September. With this year's hot, dry summer, we had to wait until late summer for downy mildew to show up. Symptoms were much less severe than normal, illustrating the key importance of moisture for development of many foliar diseases.

On upper leaf surfaces, symptoms start out as grayish to brown spots that are somewhat angular and margined by leaf veins. Eventually these lesions resemble leaf scorch and can coalesce into large areas and result in leaf drop. On the underside of the leaves, beneath the areas of upper leaf discoloration, the signs of whitish to grayish downy fungal growth of the pathogen *(Plasmopara viburni)* are seen.

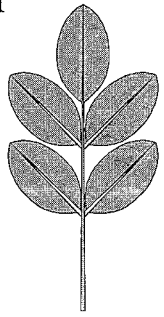
Keeping the leaves as dry as possible and cleaning up infested leaves where the overwintering stages of the fungus will survive to next year are recommended for control. Fungicides are probably not warranted in most sites during dry summers such as 2002.

Ash Anthracnose Study

In an article in the January 2002 issue of the *Journal of Arboriculture* titled "Variation in Field Susceptibility of Native and Exotic Ash Species to Anthracnose," Karel Jacobs and Donna Danielson, of the Morton Arboretum near Chicago, reported their 1997 to 1999 studies of ash anthracnose (pathogen: *Gnomoniella fraxini*). The article is quite interesting because of its relevance to the interplay of host resistance and environmental factors in the disease triangle.

Eight ash species were tested, and greatest susceptibility to ash anthracnose was demonstrated by *Fraxinus chinensis*, followed by *F. angustifolia* (Syrian ash), *F. pennsylvanica*

(green ash), and to a lesser degree, *F. mandshurica* (Manchurian ash) which was similar to *F. excelsior* (European ash).



Pumpkin ash (*F. tomentosa*) and white ash (*F. americana*) were comparatively tolerant and blue ash *(F. quadrangulata)* showed virtually no symptoms. A general trend was noted that "trees that leafed out earlier developed more disease than those that leafed out later."

Popular white ash cultivars such as 'Autumn Purple' and 'Autumn Applause' had quite low anthracnose ratings; in fact, let's give a hand to 'Autumn Applause' which had no anthracnose symptoms for any of the three years tested.

In conclusion, to quote from the article:

"Green ash is typically considered more resistant to anthracnose and white ash more susceptible." [Conversely] "Our findings... green ash appears more susceptible than white ash, although differences may be minimized in years of low disease pressure....When data from all trees were analyzed collectively, individuals that leafed out early also tended to develop more disease than those that leafed out later. These findings suggest that ontogenic resistance may operate in ash anthracnose whereby young, succulent leaves are more susceptible to infection than fully expanded leaves....This data should assist in targeting ash species for breeding programs, and in particular, suggest that the North American native blue ash would be especially promising as a source of resistance."

Disease - Not!

Horticulturists receive lots of calls about green stuff growing on tree trunks and branches. The questions are usually about whether or not the green growth is harmful to the tree. The answer is no. The green growth is sometimes moss, a type of plant which grows on all sides of trees. Or the strange growth on trunks or twigs of trees (or rocks, tombstones, etc.) is a lichen.

Lichens are mutualistic symbionts in a neat companionship between fungi and algae (or cyanobacteria). The fungi help this dual organism adhere to the surface of the stem or stone, while the algae or cyanobacteria photosynthesize, providing food. They do not damage the tree or shrub at all, though people occasionally think they do because the lichen sometimes seems to get healthier on declining plants. This occurs because in such cases, leaf drop and branch dieback let more light in for photosynthesis by the alga or cyanobacterium. Nevertheless, many perfectly healthy plants have copious lichen growth — and they are no better or worse for it.

If you want to know more about lichens, check out a fabulous new book titled, *Lichens of North America* by Irwin W. Brodi, Sylvia Duran Sharnoff, and Stephen Sharnoff.

Bacterial Fireblight

For the second straight year, fireblight on certain Callery pears and crabapples was more severe than usual in Ohio, although incidence and severity was not as common or serious as in 2001. Presumably, greater than usual problems with this bacterial disease *(Erwinia amylovora)* again this year were associated with abnormally warm, wet weather during bloom.

Blossom infections are thought to be more severe when temperatures exceed 60ºF for extended periods during bloom, and these conditions were common throughout much of the state in 2002, especially for Callery pears. Throughout Ohio, there were even periods in the mid-80s in mid-April this year.

At OSU's Secrest Arboretum in Wooster, Ohio, there are even several 'Autumn Blaze' Callery pears which will probably die from this disease, which is a very uncommon occurrence for ornamental pears. As in 2001, 'Aristocrat' callery pear was another pear which was reported to be particularly affected by fireblight throughout Ohio.

One interesting influence of fireblight from 2001 was noticed at the National Crabapple Evaluation Program plots at Secrest Arboretum in Wooster in 2002. After prolonged debate, resident crabologists Erik Draper and Jim Chatfield did not prune out the fireblight strikes from last year, with the idea that this would provide a great challenge to the plants in the evaluation plot by leaving plenty of bacterial inoculum in the plot. Fair enough — or not. Anyway, we noticed this spring that frogeye leaf spot is much more severe on trees with last year's fireblight strikes.

What's going on? Well, frogeye leaf spot is caused by the fungus *Botryosphaeria obtusa*, which also causes black rot cankers on crabapples and apples, and stem dieback on many plants, including a number of viburnums. This fungus is a great opportunist, colonizing decaying and dying branch tissue.

What happened, presumably, is that the fungus colonized the shoots killed by fireblight and then sporulated freely during early wet weather this spring, causing the explosion of frogeye leaf spot occurring on crabapple leaves adjacent to the fireblight strikes. So, by extension, this is a good lesson for all, illustrating the importance of pruning out declining and dead branches on trees. If this frog-eye leaf spot-fireblight connection sounds familiar, it just proves you were an attentive reader earlier in this article — and that the authors think this example is particularly instructive!

This discussion reminds all horticulturalists of the importance of good plant problem diagnostics. Many plant problems, resulting in the new growth dying and hooking over like a shepherd's crook, are being incorrectly diagnosed as fireblight. The shepherd's crook symptom is commonly created when new shoots on a plant wilt and then slowly dry down to form that crook shape. We have seen other plants and diseases, such as Botryosphaeria dieback on viburnum, cause that same blighted, shepherd's crook.

The best way to remember if it is fireblight is to ask yourself if the plant is in the Rosaceae family. Only plants in the Rosaceae family can be infected by fireblight. If the plant is not in the Rosaceae family, then you can rest assured that the disease is not fireblight. Of course, the next question will be, what is causing the damage?

For this answer, it will be necessary to send a sample to the C. Wayne Ellett Plant and Pest Diagnostic Center at Ohio State to have the problem identified. However, remember that the answer will only be as good as the sample sent. Don't just send a dead leaf or dead twig or the result will be inconclusive, other than just a dead leaf or twig.

The best samples are those taken from the area of transition, where normal, typical tissue changes to dead infected tissue. The greater the quantity of affected plant tissue that can be realistically sent to the Clinic, the better the chance for an accurate diagnosis.

Whole plant samples are particularly good because the roots can also tell a great story. So, for sample taking, bigger really is better!

BYGLosophys

Finally, lets close with some of the best BYGLosophys from this past year's *Buckeye Yard and Garden Line* newsletter.

Earth laughs in flowers.

— Ralph Waldo Emerson

I will be the gladdest thing under the sun! I will touch a hundred flowers, and not pick one!

— Edna St. Vincent Millay

There is nothing pleasanter than spading when the ground is soft and damp.

— John Steinbeck

Mulch — shredded magazine and newspaper gardening columns filled with tips that didn't work, placed around the base of plants to retain moisture.

— Anonymous

It seemed to my friend that the creation of a landscape-garden offered to the proper muse the most magnificent of opportunities. Here indeed was the fairest field for the display of the imagination, in the endless combining of forms of novel beauty.

— Edgar Allen Poe

Flowers always make people better, happier, and more helpful; they are sunshine, food, and medicine to the soul.

— Luther Burbank

Last night, there came a frost, which has done great damage to my garden...It is sad that nature will play such tricks with us poor mortals, inviting us with sunny smiles to confide in her, and then, when we are entirely within her power, tricking us to the heart.

— Nathaniel Hawthorne

If you have a garden and a library, you have everything you need.

— Cicero

The trouble with weather forecasting is that it's right too often for us to ignore it and wrong too often for us to rely on it.

— Patrick Young

My only desire is an intimate infusion with nature, and the only fate I wish is to have worked and lived in harmony with her laws.

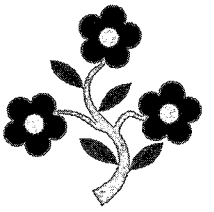
— Claude Monet

They know, they just know where to grow, how to dupe you, and how to camouflage themselves among the perfectly respectable plants, they just know, and therefore, I've concluded weeds must have brains.

— Dianne Benson

Insects won't inherit the earth — they own it now.

— Thomas Eisner



A perfect summer day is when the sun is shining, the breeze is blowing, the birds are singing, and the lawn mower is broken.

— James Dent

In nature's infinite book of secrecy

A little I can read.

— William Shakespeare

The love of gardening is a seed that once sown never dies.

— Gertrude Jekyll

All gardeners know better than other gardeners.

— Chinese Proverb

A flower is an educated weed.

— Luther Burbank

How fair is a garden amid the trials and passions of existence.

— Benjamin Disraeli

Though I do not believe that a plant will spring up where no seed has been, I have great faith in a seed. Convince me that you have a seed there, and I am prepared to expect wonders.

— Henry David Thoreau

I have often thought that if heaven had given me choice of my position and calling, it should have been on a rich spot of earth, well watered, and near a good market for the productions of the garden. No occupation is so delightful to me as the culture of the earth, and no culture comparable to that of the garden.

— Thomas Jefferson

Autumn is a second spring when every leaf is a flower.

— Albert Camus

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A Biological Calendar for Predicting Pest Activity: Six Years of Plant and Insect Phenology in Secrest Arboretum

Daniel A. Herms

Summary

Monitoring is the key to effective IPM — Integrated Pest Management. However, the tremendous diversity of ornamental plants and insect pests in landscapes and nurseries greatly complicates monitoring programs.

Because the development of both plants and insects is temperature dependent, plants accurately track degree-day accumulation and insect development. Hence, it may be possible to use the flowering sequence of trees and shrubs as a Biological Calendar for predicting insect activity.

To test this hypothesis, the author monitored the emergence of 43 key insect and mite pests and the flowering phenology of 91 ornamental plants in Secrest Arboretum (of The Ohio State University's Ohio Agricultural Research and Development Center) in Wooster, Ohio, from 1997 to 2002. Despite substantial variation in weather patterns during these six years, the order in which the phenological events occurred remained quite constant, which confirms that the phenological sequence can be used as a Biological Calendar for predicting pest emergence and scheduling pest management activities.

A phenology web site — **http://www.oardc.ohio-state.edu/gdd** — links this Biological Calendar to degree-day data for any site in Ohio in real-time.

Introduction

Effective monitoring is the backbone of any Integrated Pest Management (IPM) program. However, planning and implementing a monitoring program in nurseries and landscapes is challenging because of the tremendous diversity of plants, each with its own complement of insect pests. Furthermore, many insects are difficult to detect and observe. Consequently, pesticide applications often are scheduled on a calendar-day basis, which is frequently inaccurate because of annual and geographic variation in weather patterns.

The use of plant phenology provides an alternative approach for predicting insect activity. Phenology is the study of recurring biological events and their relationship to weather. Examples of phenological events include bird migration, flowering of plants, and the seasonal appearance of insects.

The development of both plants and insects is temperature dependent; thus plants may accurately track degree-day accumulation and insect development. If so, then it may be possible to use the flowering sequence of ornamental plants as a Biological Calendar for predicting pest emergence and scheduling pest management activities, such as monitoring programs and pesticide applications.

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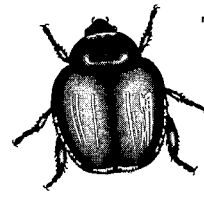
To test this hypothesis, I monitored the emergence of 43 key insect and mite pests and the flowering phenology of 91 ornamental plants in Secrest Arboretum in Wooster, Ohio, from 1997 to 2002. The critical assumption in the use of plant phenology to predict pest activity is that the phenological sequence — the order in which phenological events occur — remains constant from year to year even when weather patterns differ greatly.

The unusual weather experienced in Ohio over the last year provided an ideal opportunity for testing this assumption. Ohio experienced an especially mild fall and winter last year, which led many people to speculate that phenological patterns of plants and insects would be disrupted substantially in 2002. However, phenological patterns in Secrest Arboretum in 2002 remained highly consistent with previous years, providing strong validation of the Biological Calendar for predicting pest activity.

Methods and Materials

During 1997, the author monitored the phenology of 56 plant species and/or cultivars and 22 species of insects. From 1998 to 2002, this list was expanded to 91 plant and 43 insect and mite taxa. Four individuals of each plant species or cultivar were monitored. To control for microenvironmental variation, all individuals of a particular taxon were located either in uniform sun or shade, depending on the environment to which the species is best adapted. Plants in microenvironments obviously altered by buildings, parking lots, bodies of water, and other such factors were not included.

Plants were monitored at least three times each week, with the dates of first bloom and full bloom recorded. First bloom is defined as the date on which the first flower bud on the plant opens, revealing pistils and/or stamens, and full bloom as the date on which 95% of the flower buds have opened (i.e., one bud out of 20 has yet to open). These phenological events can be identified and recorded with precision.



The insect and mite species monitored in this study represent diverse life histories and include defoliators, wood borers, scales and other sucking insects, gall formers, leafminers, and spider mites. In contrast to methods used to monitor plant phenology, which were designed to minimize variation in order to increase predictive power, sampling protocols for insects were designed to characterize the phenology of the entire population.

Degree-days were calculated using the double sine wave method (Allen, 1976) from daily maximum and minimum temperature data for Wooster (OARDC Weather System, Wooster Station), using a base temperature of 50ºF (DD50) and a starting date of January 1. For more detail regarding the calculation and use of degree-days, see Herms, 1999 and 2001.

Results and Discussion

The phenological sequence from 1997 to 2002 is presented in Table 1. (See page 45.) Substantial variation in weather resulted in differences of up to four weeks in the dates on which these events occurred from year to year (see Table 1 for the earliest and the latest date of occurrence for each event). Most events occurred earliest in 1998, the year of El Niño, which was characterized by an early warm spring, and latest in 1997, the spring of which was quite cool.

Species that were not monitored in 1997 exhibit a more narrow range of dates in their phenology. However, dates are presented only to provide a frame of reference. Rather, it is the sequence of phenological events that is the most valuable for pest management purposes.

Despite substantial variation in degree-day accumulation, the order in which phenological events occurred was quite consistent between 1997 and 2002 (see Herms, 2002). Even the mild winter of 2001-2002 had little effect on phenological patterns. Figure 1 illustrates the high degree of correspondence between the sequence of events in 2002 and the average sequence from 1997 to 2001. Indeed, aside from first bloom of silver maple, no phenological event had its earliest date of occurrence in 2002, and cool weather in March actually delayed phenological development during early spring relative to the six-year average. Most events, however, occurred within just a few days of the six-year average (Table 1).

The mild winter had little effect on plant and insect phenology because temperatures rarely exceeded 50ºF for very long, which for most plant and insect species approximates the lower temperature threshold for development (which is why 50ºF is often used as the base temperature for calculating degree-days). Once the temperature drops below the lower threshold, physiological development ceases no matter how cold or mild the weather is.

Because phenological events occur in the same order each year, the phenological sequence can be used a Biological Calendar for predicting pest emergence and scheduling pest-management activities, such as monitoring programs and pesticide applications. This can greatly simplify the complex logistics associated with developing a monitoring and control schedule for the great diversity of insect pests in nurseries and landscapes.

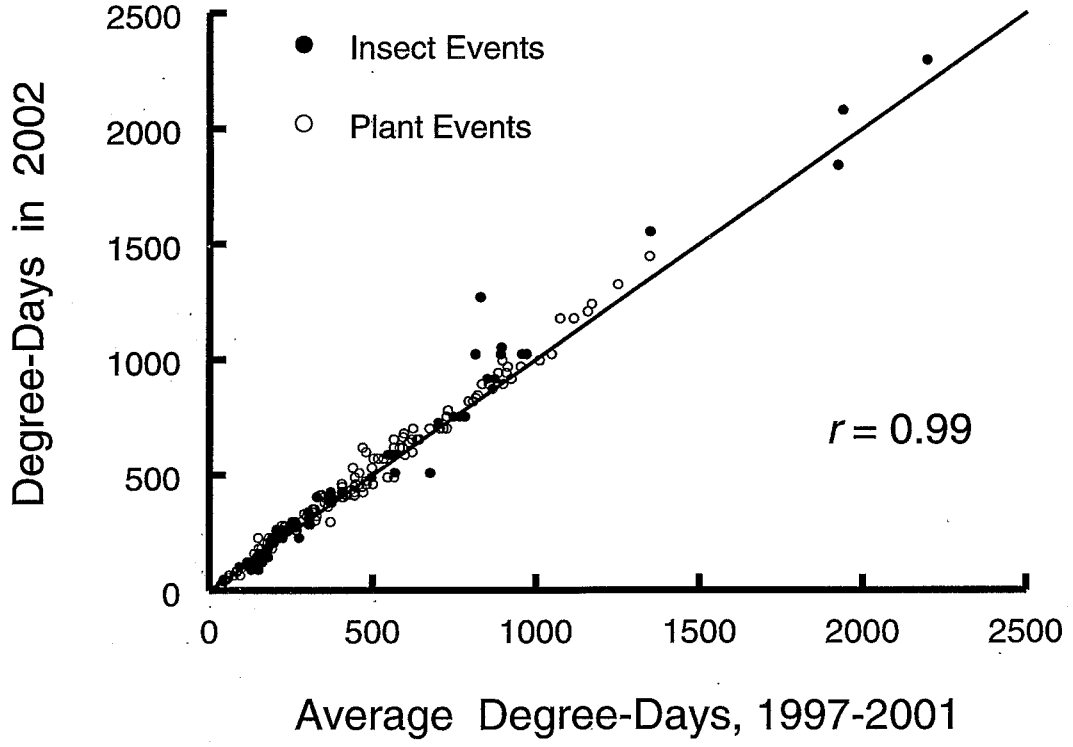


Figure 1. Comparison of the sequence of insect and plant phenological events in 2002 with their average order of occurrence from 1997 to 2001 in Secrest Arboretum, Wooster, Ohio. Rankings are based on cumulative degree-days for each event, which were calculated using a base temperature of 50ºF and a starting date of January 1. The line that bisects the graph represents exact correspondence, with the distance of a point from this line indicating degree of variation between 2002 and the average of the previous five years (r = 1.0 would indicate perfect correspondence).

For example, instead of monitoring every plant and pest species in the nursery on a weekly schedule, the Biological Calendar can be used to schedule monitoring programs only for those pests that are due to appear soon. For example, when common lilac is blooming, gypsy moth eggs have already hatched, but it is still too early to monitor for bronze birch borer emergence. Conversely, once black locust has bloomed, it is too late to control the first generation of pine needle scale.

The great consistency in the phenological sequence demonstrates that even one year of observations is useful for timing pest management decisions. This means that users can readily create, expand, and customize the Biological Calendar to suit their own purposes.

For example, a user could note what plants happened to be in bloom when a pesticide application was made (even if those plants are not included in Table 1). If follow-up monitoring showed the application to be effective, then the timing of the spray could be duplicated accurately the following season.

If the application was found to be too early or too late, then timing in future years could be delayed or accelerated relative to the phenological sequence. Any additional plants or pests can be added to the calendar by noting when they are active relative to events already included.

A phenology web site — **http://www.oardc.ohio-state.edu/gdd** — has been developed by Dave Lohnes (OARDC, Section of Communications and Technology) where cumulative degree-day data is accessible to users in real-time for any location in Ohio and is linked directly to the Biological Calendar.

Daily temperature data from the 12 OARDC Research Stations around Ohio are used to calculate cumulative degree-days in real-time for any location in the state. Degree-days for locations between weather stations are extrapolated from climatic isotherms for Ohio.

Upon entering any Ohio zip code, current degree-day accumulation for that location is calculated, and the grower is directed to the appropriate spot on the BioCalendar. Users can scroll up or down to see what pest events have already occurred, as well as what has yet to occur. The web site is still being updated with links to photos, fact sheets, as well as pests of other agricultural commodities.

In summary, this research demonstrates that this Biological Calendar can be used accurately to track degree-day accumulation and predict pest activity, because the phenological sequence of insect emergence and plant flowering remains remarkably consistent from year to year, even when weather varies considerably. Using the Biological Calendar and phenology web site to predict pest emergence and time management activities can increase the effectiveness and efficiency of pest-management programs in landscapes and nurseries, while decreasing pesticide use.

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Table 1. A Biological Calendar for Wooster, Ohio, from 1997-2002.

The phenological sequence consists of 91 plants and 43 insect and mite species. Average date of occurrence, average cumulative degree days, and the earliest and latest date on which an event occurred over the six-year period is reported, as well as date of occurrence and cumulative degree-days for 2002. Insect and mite species are indicated in bold. Common names of plants follow Dirr (1998). Cumulative degree-days were calculated using a base temperature of 50°F and a starting date of January 1.

Plant or Arthropod Taxon	Phenological Event	1997 - 2002				2002	
		Average Date	Average Degree Days	Earliest Date	Latest Date	Date	Degree Days
Silver Maple	first bloom	9-Feb	32	22-Feb	7-Mar	22-Feb	23
Corneliancherry Dogwood	first bloom	14-Mar	39	5-Mar	31-Mar	6-Mar	30
Silver Maple	full bloom	17-Mar	42	4-Mar	25-Mar	8-Mar	40
Red Maple	first bloom	21-Mar	45	6-Mar	3-Apr	11-Mar	48
Speckled Alder	first bloom	20-Mar	52	7-Mar	27-Mar	11-Mar	48
Northern Lights Forsythia	first bloom	24-Mar	58	8-Mar	1-Apr	14-Mar	56
Japanese Pieris	first bloom	26-Mar	61	14-Mar	7-Apr	23-Mar	66
Red Maple	full bloom	28-Mar	74	9-Mar	6-Apr	26-Mar	66
Star Magnolia	first bloom	1-Apr	83	23-Mar	7-Apr	4-Apr	83
Border Forsythia	first bloom	30-Mar	85	19-Mar	4-Apr	4-Apr	83
Northern Lights Forsythia	full bloom	30-Mar	89	17-Mar	8-Apr	26-Mar	66
Eastern Tent Caterpillar	**egg hatch**	**2-Apr**	**94**	**23-Mar**	**10-Apr**	**10-Apr**	**102**
Corneliancherry Dogwood	full bloom	3-Apr	98	25-Mar	9-Apr	9-Apr	97
Norway Maple	first bloom	4-Apr	115	25-Mar	11-Apr	11-Apr	109
Border Forsythia	full bloom	5-Apr	117	26-Mar	12-Apr	12-Apr	123
Larch Casebearer	**egg hatch**	**6-Apr**	**122**	**25-Mar**	**15-Apr**	**8-Apr**	**90**
Chanticleer Callery Pear	first bloom	5-Apr	123	25-Mar	12-Apr	12-Apr	123
Japanese Pieris	full bloom	8-Apr	125	29-Mar	11-Apr	11-Apr	109
Sargent Cherry	first bloom	5-Apr	126	25-Mar	12-Apr	12-Apr	123
Saucer Magnolia	first bloom	6-Apr	131	28-Mar	12-Apr	12-Apr	123
Inkberry Leafminer	**adult emergence**	**11-Apr**	**140**	**6-Apr**	**15-Apr**	**8-Apr**	**90**
Common Floweringquince	first bloom	9-Apr	141	26-Mar	23-Apr	15-Apr	159
Bradford Callery Pear	first bloom	10-Apr	141	31-Mar	21-Apr	13-Apr	136
Weeping Higan Cherry	first bloom	10-Apr	143	1-Apr	20-Apr	13-Apr	136
European Pine Sawfly	**egg hatch**	**10-Apr**	**144**	**1-Apr**	**18-Apr**	**14-Apr**	**144**
PJM Rhododendron	first bloom	12-Apr	147	1-Apr	21-Apr	14-Apr	144
Star Magnolia	full bloom	12-Apr	148	2-Apr	17-Apr	13-Apr	136
Chanticleer Callery Pear	full bloom	13-Apr	149	1-Apr	20-Apr	14-Apr	144
Spruce Spider Mite	**egg hatch**	**12-Apr**	**154**	**5-Apr**	**20-Apr**	**12-Apr**	**123**
Allegheny Serviceberry	first bloom	15-Apr	154	7-Apr	23-Apr	15-Apr	159
Spring Snow Crabapple	first bloom	16-Apr	156	6-Apr	22-Apr	15-Apr	159
Sargent Cherry	full bloom	11-Apr	157	1-Apr	20-Apr	16-Apr	181
Apple Serviceberry	first bloom	16-Apr	163	8-Apr	22-Apr	16-Apr	181
Compact Garland Spirea	first bloom	17-Apr	163	8-Apr	27-Apr	16-Apr	181
Bradford Callery Pear	full bloom	15-Apr	163	7-Apr	22-Apr	15-Apr	159
Norway Maple	full bloom	12-Apr	165	31-Mar	18-Apr	18-Apr	227
Boxwood Psyllid	**egg hatch**	**16-Apr**	**172**	**14-Apr**	**20-Apr**	**14-Apr**	**144**
Allegheny Serviceberry	full bloom	19-Apr	175	9-Apr	29-Apr	17-Apr	205
Saucer Magnolia	full bloom	18-Apr	176	15-Apr	22-Apr	16-Apr	181
Weeping Higan Cherry	full bloom	19-Apr	180	11-Apr	29-Apr	16-Apr	181
PJM Rhododendron	full bloom	19-Apr	183	8-Apr	1-May	17-Apr	205
Koreanspice Viburnum	first bloom	20-Apr	189	13-Apr	26-Apr	17-Apr	205
Eastern Redbud	first bloom	22-Apr	189	14-Apr	7-May	16-Apr	181

Table 1 (continued). A Biological Calendar for Wooster, Ohio, from 1997-2002.

Plant or Arthropod Taxon	Phenological Event	1997 - 2002 Average Date	1997 - 2002 Average Degree Days	1997 - 2002 Earliest Date	1997 - 2002 Latest Date	2002 Date	2002 Degree Days
Common Chokecherry	first bloom	21-Apr	189	15-Apr	2-May	18-Apr	227
Regent Serviceberry	first bloom	21-Apr	190	16-Apr	1-May	17-Apr	205
Apple Serviceberry	full bloom	20-Apr	190	11-Apr	29-Apr	18-Apr	227
Japanese Flowering Crab	first bloom	21-Apr	192	14-Apr	5-May	17-Apr	205
Gypsy Moth	**egg hatch**	**22-Apr**	**198**	**16-Apr**	**7-May**	**18-Apr**	**227**
Donald Wyman Crabapple	first bloom	22-Apr	198	16-Apr	4-Apr	17-Apr	205
Snowdrift Crabapple	first bloom	22-Apr	203	17-Apr	2-May	18-Apr	227
Common Floweringquince	full bloom	23-Apr	208	13-Apr	8-May	19-Apr	248
Compact Garland Spirea	full bloom	23-Apr	209	18-Apr	6-May	18-Apr	227
Spring Snow Crabapple	full bloom	23-Apr	212	17-Apr	3-May	18-Apr	227
Koreanspice Viburnum	full bloom	24-Apr	214	17-Apr	7-May	21-Apr	259
Carolina Silverbell	first bloom	24-Apr	216	18-Apr	5-May	18-Apr	227
Birch Leafminer	**adult emergence**	**25-Apr**	**217**	**18-Apr**	**5-May**	**18-Apr**	**227**
Andromeda Lace Bug	**egg hatch**	**23-Apr**	**221**	**20-Apr**	**30-Apr**	**24-Apr**	**263**
Coral Burst Crabapple	first bloom	26-Apr	224	21-Apr	11-May	21-Apr	259
Alder Leafminer	**adult emergence**	**23-Apr**	**225**	**18-Apr**	**27-Apr**	**18-Apr**	**227**
Elm Leafminer	**adult emergence**	**23-Apr**	**225**	**19-Apr**	**27-Apr**	**19-Apr**	**248**
Regent Serviceberry	full bloom	27-Apr	226	21-Apr	7-May	24-Apr	263
Common Chokecherry	full bloom	28-Apr	231	21-Apr	8-May	28-Apr	279
Honeylocust Spider Mite	**egg hatch**	**25-Apr**	**232**	**19-Apr**	**28-Apr**	**19-Apr**	**248**
Honeylocust Plant Bug	**egg hatch**	**28-Apr**	**235**	**20-Apr**	**16-May**	**20-Apr**	**258**
Wayfaringtree Viburnum	first bloom	29-Apr	236	24-Apr	10-May	27-Apr	274
Sargent Crabapple	first bloom	29-Apr	238	23-Apr	10-May	28-Apr	279
Tatarian Honeysuckle	first bloom	29-Apr	238	23-Apr	12-May	24-Apr	263
Common Lilac	first bloom	29-Apr	239	23-Apr	15-May	23-Apr	259
Persian Lilac	first bloom	30-Apr	244	24-Apr	16-May	24-Apr	263
Ohio Buckeye	first bloom	1-May	248	24-Apr	14-May	24-Apr	263
Eastern Redbud	full bloom	1-May	249	25-Apr	19-May	25-Apr	269
Snowdrift Crabapple	full bloom	2-May	256	24-Apr	15-May	30-Apr	285
Common Horsechestnut	first bloom	3-May	256	27-Apr	16-May	28-Apr	279
Donald Wyman Crabapple	full bloom	2-May	257	26-Apr	16-May	30-Apr	285
Hawthorn Lace Bug	**adult emergence**	**29-Apr**	**260**	**22-Apr**	**3-May**	**1-May**	**290**
Japanese Flowering Crab	full bloom	3-May	261	23-Apr	22-May	2-May	296
Dwarf Fothergilla	first bloom	3-May	264	23-Apr	20-May	23-Apr	259
Red Buckeye	first bloom	4-May	266	26-Apr	18-May	26-Apr	272
Imported Willow Leaf Beetle	**adult emergence**	**2-May**	**266**	**18-Apr**	**18-May**	**18-Apr**	**227**
Japanese Kerria	first bloom	3-May	267	23-Apr	20-May	23-Apr	259
Coral Burst Crabapple	full bloom	4-May	267	29-Apr	18-May	1-May	290
Hawthorn Leafminer	**adult emergence**	**30-Apr**	**268**	**29-Apr**	**3-May**	**29-Apr**	**283**
Carolina Silverbell	full bloom	4-May	269	29-Apr	17-May	29-Apr	283
Flowering Dogwood	first bloom	4-May	269	1-May	20-May	2-May	296
Blackhaw Viburnum	first bloom	4-May	272	29-Apr	19-May	29-Apr	283
Red Chokeberry	first bloom	6-May	284	2-May	19-May	2-May	296
Wayfaringtree Viburnum	full bloom	7-May	297	1-May	20-May	7-May	331
Pine Needle Scale	**egg hatch - 1st generation**	**7-May**	**302**	**30-Apr**	**3-May**	**30-Apr**	**285**

Table 1 (continued). A Biological Calendar for Wooster, Ohio, from 1997-2002.

Plant or Arthropod Taxon	Phenological Event	1997 - 2002 Average Date	1997 - 2002 Average Degree Days	1997 - 2002 Earliest Date	1997 - 2002 Latest Date	2002 Date	2002 Degree Days
Sargent Crabapple	full bloom	7-May	302	2-May	19-May	6-May	321
Cooley Spruce Gall Adelgid	**egg hatch**	**7-May**	**304**	**3-May**	**22-May**	**30-Apr**	**285**
Eastern Spruce Gall Adelgid	**egg hatch**	**7-May**	**304**	**3-May**	**22-May**	**30-Apr**	**285**
Red Horsechestnut	first bloom	7-May	305	2-May	19-May	5-May	311
Umbrella Magnolia	first bloom	8-May	308	3-May	26-May	7-May	331
Persian Lilac	full bloom	8-May	309	3-May	23-May	8-May	339
Vanhoutte Spirea	first bloom	8-May	311	4-May	25-May	6-May	321
Common Lilac	full bloom	9-May	319	3-May	26-May	8-May	339
Dwarf Fothergilla	full bloom	9-May	320	3-May	23-May	4-May	303
Pink Princess Weigela	first bloom	9-May	322	1-May	20-May	9-May	351
Blackhaw Viburnum	full bloom	9-May	325	4-May	22-May	8-May	339
Winter King Hawthorn	first bloom	9-May	327	5-May	26-May	6-May	321
Redosier Dogwood	first bloom	10-May	328	5-May	27-May	9-May	351
Lilac Borer	**adult emergence**	**11-May**	**343**	**3-May**	**30-May**	**16-May**	**404**
Slender Deutzia	first bloom	12-May	350	6-May	29-May	17-May	411
Common Horsechestnut	full bloom	13-May	355	5-May	29-May	18-May	413
Doublefile Viburnum	first bloom	12-May	357	5-Jul	27-May	13-May	380
Common Sweetshrub	first bloom	12-May	358	2-May	4-Jun	2-May	296
Red Chokeberry	full bloom	12-May	360	7-May	26-May	16-May	404
Pagoda Dogwood	first bloom	13-May	363	7-May	30-May	11-May	363
Red Java Weigela	first bloom	13-May	368	6-May	29-May	14-May	386
Black Cherry	first bloom	13-May	371	9-May	29-May	14-May	386
Ohio Buckeye	full bloom	14-May	375	8-May	31-May	13-May	380
Holly Leafminer	**adult emergence**	**14-May**	**380**	**9-May**	**29-May**	**16-May**	**404**
Lesser Peach Tree Borer	**adult emergence**	**15-May**	**381**	**10-May**	**4-Jun**	**23-May**	**425**
Vanhoutte Spirea	full bloom	16-May	405	12-May	1-Jun	16-May	404
Winter King Hawthorn	full bloom	16-May	407	14-May	5-Jun	16-May	404
Euonymus Scale	**egg hatch - 1st generation**	**17-May**	**409**	**11-May**	**30-May**	**23-May**	**425**
Tatarian Honeysuckle	full bloom	16-May	409	12-May	28-May	16-May	404
Catawba Rhododendron	first bloom	18-May	414	9-May	2-Jun	25-May	448
Ohio Pioneer Thicket Hawthorn	first bloom	18-May	415	6-May	26-May	26-May	460
Beautybush	first bloom	17-May	417	11-May	3-Jun	18-May	413
Black Cherry	full bloom	18-May	418	13-May	3-Jun	21-May	414
Miss Kim Manchurian Lilac	first bloom	18-May	421	12-May	4-Jun	21-May	414
White Fringetree	first bloom	20-May	435	12-May	9-Jun	24-May	436
Bush Cinquefoil	first bloom	19-May	439	14-May	8-Jun	17-May	411
Red Prince Weigela	first bloom	19-May	441	13-May	3-Jun	18-May	413
Snowmound Nippon Spirea	first bloom	20-May	441	13-May	9-Jun	23-May	425
Doublefile Viburnum	full bloom	20-May	445	15-May	1-Jun	25-May	448
Redosier Dogwood	full bloom	21-May	450	14-May	5-Jun	26-May	460
Pink Princess Weigela	full bloom	21-May	454	13-May	2-Jun	28-May	490
Red Horsechestnut	full bloom	21-May	456	13-May	2-Jun	30-May	531
Red Buckeye	full bloom	22-May	463	15-May	7-Jun	23-May	425
Black Locust	first bloom	21-May	464	14-May	9-Jun	25-May	448

Table 1 (continued). A Biological Calendar for Wooster, Ohio, from 1997-2002.

Plant or Arthropod Taxon	Phenological Event	1997 - 2002 Average Date	Average Degree Days	Earliest Date	Latest Date	2002 Date	2002 Degree Days
Scarlet Firethorn	first bloom	22-May	468	15-May	9-Jun	29-May	509
Pagoda Dogwood	full bloom	23-May	476	15-May	9-Jun	26-May	460
Common Ninebark	first bloom	23-May	477	16-May	9-Jun	27-May	472
Sweet Mockorange	first bloom	23-May	478	16-May	8-Jun	26-May	460
Smokebush	first bloom	24-May	495	17-May	12-Jun	26-May	460
Ohio Pioneer Thicket Hawthorn	full bloom	25-May	495	23-May	5-Jun	4-Jun	618
Oystershell Scale	**egg hatch**	**24-May**	**496**	**17-May**	**9-Jun**	**28-May**	**490**
Umbrella Magnolia	full bloom	24-May	500	15-May	9-Jun	3-Jun	599
Miss Kim Manchurian Lilac	full bloom	25-May	503	15-May	9-Jun	30-May	531
Catawba Rhododendron	full bloom	26-May	515	15-May	10-Jun	1-Jun	571
White Fringetree	full bloom	26-May	526	17-May	13-Jun	1-Jun	571
American Yellowwood	first bloom	27-May	537	23-May	13-Jun	28-May	490
Arrowwood Viburnum	first bloom	28-May	540	18-May	12-Jun	1-Jun	571
Sweetbay Magnolia	first bloom	28-May	553	17-May	22-Jun	28-May	490
Bronze Birch Borer	**adult emergence**	**28-May**	**553**	**18-May**	**12-Jun**	**2-Jun**	**587**
Black Locust	full bloom	28-May	554	21-May	14-Jun	2-Jun	587
Multiflora Rose	first bloom	29-May	554	18-May	14-Jun	2-Jun	587
Potato Leafhopper	**adult arrival**	**29-May**	**558**	**21-May**	**16-Jun**	**29-May**	**509**
American Holly	first bloom	29-May	561	20-May	13-Jun	2-Jun	587
Red Java Weigela	full bloom	29-May	569	17-May	14-Jun	2-Jun	587
Juniper Scale	**egg hatch**	**29-May**	**574**	**19-May**	**14-Jun**	**2-Jun**	**587**
Scarlet Firethorn	full bloom	31-May	574	18-May	8-Jun	4-Jun	618
Mountain-laurel	first bloom	31-May	580	20-May	12-Jun	6-Jun	654
Snowmound Nippon Spirea	full bloom	31-May	589	20-May	14-Jun	4-Jun	618
American Yellowwood	full bloom	29-May	596	26-May	2-Jun	2-Jun	587
Beautybush	full bloom	1-Jun	597	19-May	17-Jun	4-Jun	618
Chinese Dogwood	first bloom	2-Jun	604	23-May	15-Jun	7-Jun	663
Common Ninebark	full bloom	2-Jun	610	21-May	15-Jun	8-Jun	679
Smokebush	full bloom	3-Jun	616	22-May	17-Jun	5-Jun	642
Japanese Tree Lilac	first bloom	2-Jun	618	23-May	21-Jun	3-Jun	599
Arrowwood Viburnum	full bloom	3-Jun	627	24-May	17-Jun	6-Jun	654
Bumald Spirea	first bloom	4-Jun	637	27-May	14-Jun	9-Jun	701
Washington Hawthorn	first bloom	4-Jun	639	26-May	20-Jun	6-Jun	654
Black Vine Weevil	**adult emergence**	**30-May**	**643**	**22-May**	**10-Jun**	**29-May**	**509**
American Holly	full bloom	4-Jun	644	26-May	19-Jun	6-Jun	654
Multiflora Rose	full bloom	4-Jun	645	24-May	18-Jun	6-Jun	654
Northern Catalpa	first bloom	7-Jun	679	28-May	22-Jun	9-Jun	701
American Elder	first bloom	8-Jun	706	28-May	22-Jun	9-Jun	701
Greater Peach Tree Borer	**adult emergence**	**6-Jun**	**707**	**1-Jun**	**12-Jun**	**10-Jun**	**726**
Sweet Mockorange	full bloom	8-Jun	715	29-May	24-Jun	9-Jun	701
Fuzzy Deutzia	first bloom	6-Jun	722	2-Jun	9-Jun	9-Jun	701
Red Prince Weigela	full bloom	9-Jun	732	25-May	20-Jun	11-Jun	753
Washington Hawthorn	full bloom	9-Jun	739	31-May	24-Jun	12-Jun	780
Calico Scale	**egg hatch**	**7-Jun**	**749**	**30-May**	**14-Jun**	**11-Jun**	**753**
European Fruit Lecanium Scale	**egg hatch**	**8-Jun**	**764**	**1-Jun**	**14-Jun**	**11-Jun**	**753**
Striped Pine Scale	**egg hatch**	**9-Jun**	**777**	**4-Jun**	**14-Jun**	**11-Jun**	**753**
Winterberry Holly	first bloom	10-Jun	799	3-Jun	14-Jun	14-Jun	819

Table 1 (continued). A Biological Calendar for Wooster, Ohio, from 1997-2002.

Plant or Arthropod Taxon	Phenological Event	1997 - 2002 Average Date	1997 - 2002 Average Degree Days	1997 - 2002 Earliest Date	1997 - 2002 Latest Date	2002 Date	2002 Degree Days
Japanese Tree Lilac	full bloom	13-Jun	810	4-Jun	28-Jun	14-Jun	819
Northern Catalpa	full bloom	13-Jun	819	6-Jun	25-Jun	15-Jun	833
Mountain-laurel	full bloom	14-Jun	826	8-Jun	25-Jun	16-Jun	845
Oakleaf Hydrangea	first bloom	13-Jun	846	9-Jun	19-Jun	19-Jun	893
Rhododendron Borer	**adult emergence**	**13-Jun**	**857**	**6-Jun**	**24-Jun**	**24-Jun**	**1023**
Cottony Maple Scale	**egg hatch**	**14-Jun**	**864**	**8-Jun**	**17-Jun**	**20-Jun**	**916**
Panicle Hydrangea	first bloom	14-Jun	866	11-Jun	19-Jun	19-Jun	893
Fall Webworm	**egg hatch**	**17-Jun**	**868**	**12-Jun**	**24-Jun**	**18-Jun**	**874**
Mimosa Webworm	**egg hatch - 1st generation**	**14-Jun**	**882**	**12-Jun**	**20-Jun**	**20-Jun**	**916**
Fuzzy Deutzia	full bloom	15-Jun	896	13-Jun	21-Jun	21-Jun	942
Greenspire Littleleaf Linden	first bloom	18-Jun	898	12-Jun	30-Jun	19-Jun	893
American Elder	full bloom	19-Jun	915	12-Jun	28-Jun	21-Jun	942
Winterberry Holly	full bloom	16-Jun	917	13-Jun	23-Jun	23-Jun	996
Dogwood Borer	**adult emergence**	**15-Jun**	**918**	**31-May**	**28-Jun**	**3-Jul**	**1269**
Winged Euonymus Scale	**egg hatch**	**16-Jun**	**918**	**12-Jun**	**24-Jun**	**24-Jun**	**1023**
Spruce Budscale	**egg hatch**	**18-Jun**	**921**	**12-Jun**	**30-Jun**	**25-Jun**	**1052**
Panicled Goldenraintree	first bloom	19-Jun	923	14-Jun	7-Jul	20-Jun	916
Southern Catalpa	first bloom	16-Jun	924	14-Jun	22-Jun	22-Jun	969
June Bride Littleleaf Linden	first bloom	19-Jun	957	17-Jun	22-Jun	22-Jun	969
Azalea Bark Scale	**egg hatch**	**19-Jun**	**970**	**17-Jun**	**24-Jun**	**24-Jun**	**1023**
Japanese Beetle	**adult emergence**	**22-Jun**	**979**	**17-Jun**	**24-Jun**	**24-Jun**	**1023**
Rosebay Rhododendron	first bloom	23-Jun	1008	16-Jun	7-Jul	23-Jun	996
Greenspire Littleleaf Linden	full bloom	24-Jun	1043	16-Jun	6-Jul	24-Jun	1023
Southern Catalpa	full bloom	25-Jun	1094	21-Jun	30-Jun	30-Jun	1177
June Bride Littleleaf Linden	full bloom	27-Jun	1131	25-Jun	30-Jun	30-Jun	1177
Bottlebrush Buckeye	first bloom	28-Jun	1167	23-Jun	29-Jun	1-Jul	1207
Ural Falsespirea	first bloom	29-Jun	1187	26-Jun	2-Jul	2-Jul	1239
Panicled Goldenraintree	full bloom	5-Jul	1263	23-Jun	7-Jul	5-Jul	1323
Rose-of-Sharon	first bloom	9-Jul	1372	2-Jul	12-Jul	11-Jul	1445
Pine Needle Scale	**egg hatch - 2nd generation**	**8-Jul**	**1390**	**30-Jun**	**16-Jul**	**16-Jul**	**1553**
Euonymus Scale	**egg hatch - 2nd generation**	**26-Jul**	**1907**	**30-Jul**	**30-Jul**	**27-Jul**	**1840**
Magnolia Scale	**egg hatch**	**4-Aug**	**1961**	**2-Aug**	**8-Aug**	**4-Aug**	**2078**
Banded Ash Clearwing Borer	**adult emergence**	**14-Aug**	**2220**	**13-Aug**	**17-Aug**	**14-Aug**	**2295**

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Biological Suppression of Foliar Diseases of Ornamental Plants with Composted Manures, Biosolids, and *Trichoderma hamatum* 382

Harry A. J. Hoitink, Carol A. Musselman, Terry L. Moore, Leona E. Horst, Charles R. Krause, Randy A. Zondag, and Hannah Mathers

Summary

Composted dairy and swine manures and municipal biosolids were tested as amendments in nursery container media to determine their effects on plant growth and health. These composts, when incorporated into nursery media at a volumetric amendment rate of 5 to 6 %, suppressed root rots and provided excellent growth on all but one of 40 plant species tested.

Viola, a low-fertility crop that did not respond well initially, recovered later in the season. One batch of composted manure naturally suppressed a foliar disease as well.

However, several other batches of composts, including several batches of composted dairy and swine manures and composted municipal biosolids tested in cooperating nurseries, did not suppress foliar diseases. Inoculation of these compost-amended media with *Trichoderma hamatum* 382, a biocontrol agent that induces systemic resistance to disease in plants, significantly reduced the severity of several different types of foliar diseases.

In conclusion, inoculation of compost-amended container media with *T. hamatum* 382 suppressed root as well as foliar diseases and supported excellent growth of nursery stock.

Introduction

Environmental problems caused by application of raw manures and biosolids have made composting an increasingly attractive process to municipalities and more recently also to farmers. Because costs associated with composting typically are higher, composts of high quality must be produced consistently so that they can be distributed into value-added markets.

The peat substitute aspect of composted manures and biosolids used in potting mixes is the most value-added property of composts. Biological suppression of root rots provided by composts has resulted in reduced pesticide use, and this is the second most value-added benefit associated with compost utilization. Composted biosolids and manures release essential micronutrients that can serve as excellent substi-

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tutes for mineral additives. This represents the third most valuable property of composted manures and biosolids.

It has been recognized for centuries that composts may suppress root rots. It was established recently, however, that composts may also suppress foliar diseases of plants (1, 4). Unfortunately, a survey of 80 different types of composted products performed from 1997 to 2001 revealed that only one of these composts naturally induced systemic resistance to foliar diseases even though all 80 compost-amended media suppressed Pythium root rot. Thus, suppression of foliar diseases with composts is a rare phenomenon with considerable unreliability for growers.

However, several different biocontrol agents were isolated from this rare batch of compost that induced resistance in plants. *Trichoderma hamatum* 382 (T382) was identified as the most active inducer of resistance. For that reason, it was included in demonstration trials with composted manures and biosolids on several different ornamental crops. In this report the authors present data from demonstration trials performed in Ohio nurseries in 2002.

Materials and Methods

Composts evaluated in this work included:

- A dairy sawdust-bedded composted cow manure produced at The Ohio State University, Ohio Agricultural Research and Development Center (OSU/OARDC), Wooster, Ohio.
- A swine manure amended with ground wood and shavings produced in a High Rise Hog® facility and composted at OSU/OARDC, Wooster, Ohio, according to Keener *et al.*, 2001 (2) or at Fresh Aire Farms, 1324 Wasson Road, Union City, Ohio.
- Composted municipal biosolids received from the Akron Composting Facility.

All composts had been stabilized to a stability level suitable for incorporation into potting mixes. The composted manures were incorporated into potting mixes at a volumetric amendment rate of 5% and the composted biosolids at 6%. The types and quality of lime and fertilizers added varied with the location of the test and the crop, but all crops were treated with slow-release fertilizer. The pH of all mixes ranged from 5.3 to 6.0. The air-filled pore space after saturation and drainage exceeded 25% in 1-gallon containers.

All trials were arranged as a randomized complete block design with at least four blocks. The number of replicates used per block depended on plant availability and varied among but not within plant species. Plant growth was expressed as dry weight, plant canopy size, or on the basis of a salability rating scale. Disease severity was based on severity ratings scales, area under disease progress curves, or percent of plants killed or symptomless, depending upon the species or the disease. Data were analyzed by ANOVA, and means were separated by Fisher's least significant difference test.

Results and Discussion

Suppression of Powdery Mildew of Begonia with Composted Dairy Manure and T382

The protective effects of the compost were tested in a light fibrous Sphagnum peat mix that is used widely for greenhouse crops. Data in Table 1 show that the severity of powdery mildew on *Begonia hiemalis* 'Barbara' plants grown from rooted cuttings in a light fibrous H_2 - H_3 on the von Post peat decomposition scale Sphagnum peat mix (70% peat, 30% perlite, v/v) was controlled on plants sprayed with the fungicide Piperon.

Furthermore, plant dry weights and the salability of plants also were significantly higher on plants sprayed with Piperon. Inoculation of the peat mix with the biocontrol agent T382 was at least as effective as the Piperon treatment. Amendment of the peat mix with 5% composted dairy manure also suppressed the disease. Both treatments increased plant dry weight and improved salability. Neither Piperon nor T382 added to the protective effect induced by this batch of composted dairy manure.

In conclusion, this specific batch of composted dairy manure naturally suppressed powdery mildew. This compost treatment and T382 were as effective as the fungicide Piperon. The effect is best explained on the basis of systemic-induced resistance. This effect is highly unusual because most composts do not induce this effect naturally.

Suppression of Botryosphaeria Stem Blight and Dieback on *Myrica pensylvanica* Induced by T382 in a Composted Biosolids-Amended Container Medium

Liners of *Myrica pensylvanica* (Northern Bayberry) were transplanted on March 20, 2002, in 1-gallon containers into a potting mix containing aged pine bark, light fibrous Sphagnum peat, composted biosolids, expanded shale, and sand at volumetric ratios of 9.0:1.5:0.75:1.0:0.33. The same mix, but inoculated with 7 oz. granular inoculum of T382 per cubic yard of mix, served as a second treatment.

Shortly after transplanting, a stem blight and dieback disease caused by *Botryosphaeria dothidea* developed. Progress of this stress disease declined in early May, and on May 16, final disease severity values were determined.

Table 1: Systemic Control of Powdery Mildew of Begonia (*Begonia Hiemalis* 'Barbara') Provided by a Composted Cow Manure-Amended Potting Mix and *Trichoderma hamatum* 382.

Potting[1] Mix	Control[2] Treatment	Disease Severity[3] (AUDPC)	Dry Weight[4] (gm)	Salability[5]
peat	control	1,402.8 a	4.6 c	2.6 c
peat	Piperon	363.2 bc	7.1 ab	3.7 b
peat	T382	100.3 c	7.5 a	4.4 a
SD compost	control	347.3 bc	5.7 bc	3.9 ab
SD compost	Piperon	216.8 bc	7.6 a	4.1 ab
SD compost	T382	521.4 b	7.0 ab	3.8 ab

[1] Peat mix (Sphagnum peat, perlite; 7:3, vol./vol.). SD compost represents 5% of peat replaced with sawdust-bedded composted cow manure.

[2] Piperon applied biweekly as a topical spray to the foliage; T382 was incorporated into the potting mix at 3 oz. of a granular preparation of T382 per cubic yard of mix.

[3] Area under the disease progress curve based on mean disease severity ratings (n = 9); values followed by the same letters do not differ significantly based on Fisher's LSD test.

[4] Mean dry wt. (g) per plant (n = 9) determined 55 days after potting.

[5] Mean salability (n = 9) at flowering based on the following rating scale: 5 = healthy with 1 or more flower stalks with at least 1 flower open; 4 = with buds or flower stalks with minimal damage to leaves; 3 = no flowers or flowers with minimal damage; 2 = no flowers, small and/or damaged plants; 1= dead plant.

Data in Table 2 reveal that inoculation of the composted biosolids-amended mix with T382 significantly affected the severity of this stress disease. In the compost amended mix, 20.8% of the plants were killed, and only 25% of the plants were symptomless. Most were stunted in growth. Only 6.3% of the plants in the T382-inoculated mix were killed, and 66.7% of the plants were symptomless.

In conclusion, this batch of natural composted biosolids-amended mix did not provide control of the foliar and stem disease. In contrast, inoculation of the mix with T382 provided effective control of Botryosphaeria dieback. The results of this demonstration trial are in line with controlled greenhouse studies which showed that composts generally do not provide systemic effects against plant diseases unless inoculated with biocontrol agents that can activate systemic resistance.

Effects of Composted Cow Manure and T382 on Growth of Perennials and Ground Cover Plants

Liners of *Ajuga, Sedum,* and *Viola* were transplanted on June 14, 2002, into 1-gallon containers.

Container mix treatments were:

1. The grower medium (aged pine bark and composted rice hulls; 8:3, v/v).
2. The same mix but amended with composted dairy manure (5%; v/v).
3. This mix but inoculated with T382 using 3 oz. of granular inoculum of T382 per cubic yard of mix.

The mean number of flower stalks per plant and canopy size were determined at the completion of the growing season for *Ajuga* 'Burgundy Glow.' A mean salability rating was determined for *Sedum* 'Autumn Joy' and *Viola* 'Purple Showers.' A randomized complete block design was used with four blocks of 12 plants per treatment.

Amendment of the grower mix with composted dairy manure significantly increased the number of flower stalks and canopy size on *Ajuga* 'Burgundy Joy' (Table 3). Salability of *Sedum* 'Autumn Joy' also was drastically improved by amendment with the compost. *Viola* 'Purple Showers' was stunted in growth during the first six weeks after potting in the mix amended with composted cow manure.

Table 2. Suppression of Botryosphaeria Stem Blight and Dieback of *Myrica pensylvanica* by *Trichoderma hamatum* 382 (T382) in a Composted Biosolids-Amended Container Medium.

Potting Mix[1]	Mean Dieback Severity[2]	Mean % Plants Killed[2]	Mean % Symptomless Plants
control	2.4	20.8	25.0
T382	1.5	6.3	66.7
LSD 0.05	0.4	14.1	20.4

[1] Liners potted on March 20, 2002, in 1-gallon pots in a container medium consisting of "aged" pine bark, sphagnum peat, composted biosolids, expanded shale, and sand (9:1.5:0.75:1:0.33; vol./vol.) (control) or inoculated with 7 oz. of T382 granular inoculum per cubic yard of mix (T382).

[2] Mean dieback severity based on four blocks of 12 plants per treatment (n = 48) determined on May 16, 2002, using a scale in which 1 = symptomless, 2 = slight stunting, 3 = severe stunting, and 4 = dead plant.

Symptoms suggested that the ammonium concentration in the mix at planting was too high and caused phytotoxicity. Towards the end of the 2002 growing season, *Viola* plants had recovered, and the mean salability did not differ from that in the mix not amended with the composted manure.

The 2002 summer was extremely dry where this demonstration test was performed. As a result, disease pressure was low, and foliar diseases did not develop. Root rots also were not observed on plants in any of the mixes even though fungicide drenches were not applied. Within days after potting, some *Sedum* plants randomly distributed across the treatments developed Phytophthora stem blight. Conditions were too dry for spread of the disease, however.

T382, as expected, had no major effect on *Ajuga* or *Sedum* because of low disease pressures. On *Viola* where phytotoxicity was observed, salability was affected negatively. The inducing effect of T382 may have interacted with the toxicity that apparently was caused by excessive ammonium concentrations early after potting in the composted cow manure-amended mix.

In conclusion, amendment of the grower mix with composted cow manure improved growth on two species and caused a temporary setback on *Viola*, a plant known to require low fertility conditions. Disease pressures were too low to allow observations on T382.

Suppression of Phytophthora Leaf Blight and Stem Dieback of *Pieris japonica* with T382

Liners of *Pieris japonica* (pint-sized pots) were transplanted into 1-gallon containers on June 3, 2002.

Table 3. Effects of a Composted Cow Manure-Amended Potting Mix and of *Trichoderma hamatum* 382 (T382) on Growth and Flowering of *Ajuga* 'Burgundy Glow,' *Sedum* 'Autumn Joy,' and *Viola* 'Purple Showers.'

Potting Mix[1]	*Ajuga* 'Burgundy Glow'[2]		*Sedum* 'Autumn Joy'[3] Salability Rating	*Viola* 'Purple Showers'[3] Salability Rating
	Canopy Size (L)	# Flower Stalks per plant		
Grower control mix	0.6	2.4	3.7	3.7
SD compost	1.5	3.0	4.2	3.9
SD compost+ T382	1.4	2.8	4.2	3.2
LSD 0.05	0.5	0.2	0.4	0.4

[1] Grower mix consisting of aged pine bark and composted rice hulls (8:3; vol./vol.) was amended with sawdust-bedded composted cow manure (5%; vol./vol.) (SD compost) or the same and inoculated with 100 g granular inoculum of T382 per cubic yard of mix.

[2] Planted on June 14, 2002. Mean number of flower stalks per plant (n = 48) determined on August 7, 2002, and canopy size determined on September 3, 2002.

[3] Planted on June 14, 2002. Mean salability (n = 48) determined on August 7, 2002, based on a scale in which: 5 = full height, large flower; 4 = full height, small flower; 3 = slightly stunted, chlorotic; 2 = severe stunting and chlorosis with stem lesion caused by Phytophthora dieback; 1 = dead plant.

Container media included:

1. The grower's container medium consisting of aged pine bark, fibrous Sphagnum peat, composted dairy manure, expanded shale, and silica sand (65:15:5:13:2, v/v).

2. The same mix but inoculated with 4 oz. of a granular preparation of T382.

During a week of rainy weather in late July, 2002, a severe epidemic of Phytophthora dieback developed on *Pieris* on blocks of 525 plants produced in each medium. The percentage of plants with severe dieback or killed by the disease in the mix inoculated with T382 (4%) was considerably below the value observed on plants in the composted cow-manure-amended medium (26%).

In conclusion, this batch of compost did not naturally suppress this disease and that agreed with laboratory studies not presented here. Inoculation of the mix during its formulation in the cooperating nursery with T382 proved effective for suppression of Phytophthora dieback of *Pieris japonica.*

Preliminary Data on Growth in Composted Swine-Manure-Amended Media

Composted hog manure was amended into a container medium on May 17, 2002. Media used at this nursery included:

1. The grower's mix consisting of aged pine bark, composted rice hulls, Sphagnum peat, and pea gravel (41:25:13.7:12.3; v/v).

2. The same mix but amended with 5% composted swine manure.

3. This hog manure compost-amended mix inoculated with 3 oz. of granular inoculum of T382 per cubic yard of mix.

Eighteen different woody ornamentals, including cultivars highly susceptible to foliar diseases (e.g., bacterial leaf spots and blights, Phytophthora dieback diseases), were planted in each of the three mixes. A randomized complete block design was used for each treatment utilizing four blocks of 12 2-gallon containerized plants per treatment.

The severity of foliar diseases was monitored throughout the summer. Fungicide drenches were not applied to the crops. Foliar diseases did not develop on any of the crops due to extremely dry weather conditions. In late September 2002, the severity of root rot and the canopy size were determined for each treatment.

Mean root rot severity and the mean canopy size values for each crop did not differ significantly among treatments. In conclusion, composted hog manure served as an effective alternative amendment in the container medium used at this nursery. Neither beneficial nor detrimental effects were observed. T382 did not provide a response, probably due to the extremely low disease pressures that prevailed during the dry summer of 2002 at this location.

Conclusions

Composted dairy and swine manures incorporated into container media served as effective substitutes for similar products such as composted biosolids used more widely in Ohio nurseries. One single batch of composted cow manure tested in this work naturally suppressed the severity of a foliar disease. However, several other batches of composts that were tested did not provide control of foliar diseases even though they suppressed root rots. In cooperating nurseries where wet weather conditions occurred for a week or longer and where disease pressures were high for that reason and foliar diseases developed, inoculation of these container media at potting with T382 significantly reduced the severity of the foliar diseases and/or stem blights.

Finally, the sporadic occurrence of natural suppression of foliar diseases on plants produced in compost-amended media agrees with earlier laboratory studies which showed that the nursery industry cannot rely on natural composts for control of foliar diseases. The effect of T382 was promising and requires further analysis.

Acknowledgments

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Growth and Water Use by Four Leguminous Tree Species in Containers on a Gravel Surface or Embedded in Mulch

Michael Knee, Daniel K. Struve, Michael H. Bridgewater, and Joseph W. Phillips

Introduction

The Ohio production system allows trees to be produced from seed or cuttings and grown to marketable size in two to three years (Struve, 1996). After the first year of growth in the greenhouse, the trees are grown in copper-treated containers. In many nurseries, containers are placed on the ground, on a gravel or fabric surface. This exposes them to the sun, which causes the temperature in the root zone to rise as high as 50ºC and can lead to inhibition of growth or even death of roots (Struve, unpublished observations).

Some nurseries have adopted the "pot in pot" system of production, whereby each container is set within an outer container that is sunk in the ground (Parkerson, 1990). This protects the pot from heat input at the sides and has the further advantage of natural protection from freezing during the winter.

There have been few direct comparisons of root growth, water use, and overall plant performance for trees in conventional and pot-in-pot systems. The authors set out to determine whether some of the predicted advantages of the pot-in-pot system were realized in practice. We were also interested in comparing the water usage of four Ohio-native tree species in the Fabaceae family, in the context of nursery production and potential for use in dry landscape situations.

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Materials and Methods

Seeds of *Gleditsia triacanthos* (honeylocust), *Gymnocladus dioicus* (Kentucky coffee tree), and *Cercis canadensis* (redbud) were obtained from local (Columbus) trees. Seeds of *Robinia pseudoacacia* (black locust) were purchased from Sheffield Seeds (Locke, New York).

Individual seeds were germinated in April 2000 in 10 cm square pots containing Metromix 360 (Scotts Sierra Horticultural Products Co., Marysville, Ohio). Seedlings were grown in the greenhouse until October when they were potted up in the same medium in 25 cm dia. containers and coated internally with Spinout (Griffin Corp., Valdosta, Georgia). The containers were over-wintered in a bed of shredded woody prunings provided by the Ohio State grounds staff.

In early June 2001 the containers were rearranged so that half remained in mulch and half were placed on a limestone gravel bed. The gravel and mulch areas were arranged in six blocks. Each container was irrigated with a spray emitter (Spot-Spitter, Roberts Irrigation, San Marcos, California) that delivered 2 L of water twice a day. For one irrigation cycle each week, the water

was replaced by liquid fertilizer (Peters Professional 20:20:20, Scotts Sierra Horticultural Products Co., Marysville, Ohio) at 200 mg L-1 N.

On June 18, July 30, and October 3, six trees of each species in mulch and on gravel were disconnected from the irrigation system. The surface of the medium of three trees in each group was covered with aluminum foil in an attempt to minimize evaporation from the container. Each pot and tree was weighed between 9 and 10 a.m. for three consecutive days to measure water loss. If a tree and pot fell below 4 kg, it was watered and weighed again.

After three days, the length of the main stem was measured, and the leaf area was measured using a Licor 3600 meter (Licor, Lincoln, Nebraska). Roots were washed free of medium, and root and shoot (stem and leaf) dry weights were obtained after drying at 60ºC for 7 days.

The temperature of the medium in the containers was measured on three days in August using an Aquaterr soil moisture meter (Geneq, Inc., Montreal, Canada).

Meteorological data were collected during the experiment with an ET 106 weather station (Campbell Scientific, Logan, Utah). Six remaining trees of each species from gravel and mulch were held over the winter in a mulch bed and planted at random in the Ohio State University Chadwick Arboretum in early April 2002. Their heights were measured at planting and again at the beginning of October.

Data were subjected to analysis of variance or regression analysis using SAS 8e (SAS Institute, Cary, North Carolina). The significance of treatment effects is shown in Table 1.

Results

The temperature of the medium in the containers was measured on three sunny afternoons when average air temperature was 30.3ºC. There was a slight but significant difference ($p = 0.01$) between pots in mulch (25.4ºC) and gravel (26.0ºC). Containers of medium without trees lost more water (0.261 kg) on gravel than those in mulch (0.205 kg). The difference was significant ($p = 0.001$), and the loss from a container in mulch was equivalent to the average recorded evapotranspiration for the 5 days of measurement (4.36 mm).

Table 1. Significance of Effects of Species, Location in Mulch or on Gravel and Their Interaction (S*L) for Data Presented in Other Tables and Figures.

Data	Presented	Probability of Null Effect		
		Species	Location	S*L
Tree height	Figure 1	0.0001	0.891	0.104
Root dry weight	Figure 2	0.0001	0.039	0.545
Shoot dry weight	Figure 3	0.0001	0.187	0.033
Leaf area	Figure 4	0.0001	0.458	0.978
Tree height	Table 2	0.0001	0.866	0.200

Robinia pseudoacacia (black locust) was the fastest-growing species, reaching 2 m in height by the second harvest in July (Figure 1). *Cercis canadensis* (redbud) and *Gleditsia triacanthos* (honeylocust) reached a similar height by the third harvest in October, but *Gymnocladus dioicus* (Kentucky coffee tree) did not exceed 0.5 m. *R. pseudoacacia* trees were slightly taller when grown in mulch than on gravel, whereas the opposite was true for *G. triacanthos* (Figure 1).

R. pseudoacacia developed a root system that filled the containers with a dense mat of fibrous roots by the second harvest. Roots of *C. canadensis* approached a similar density by the third harvest, whereas the roots of the two other species did not completely fill the containers. The dry weights of roots were higher for containers in mulch than on gravel for all species by the third harvest (Figure 2).

R. pseudoacacia produced much higher shoot dry weight than the other species, mainly because of its massive stem development (Figure 3). *R. pseudoacacia* in mulch had higher shoot dry weight than on gravel, particularly at the second harvest, whereas *G. triacanthos* had higher shoot dry weight on gravel (Figure 3).

Leaf areas were also highest in *R. pseudoacacia* except at the end of the experiment when leaf fall was occurring in this species, and at this time *C. canadensis* had developed more leaf area than the other species (Figure 4). Leaf areas were similar for trees in mulch and on gravel.

Water consumption was estimated from the change in weight of containers, recorded on three successive days three times during the growing season. We hoped to be able to discriminate between water consumption by

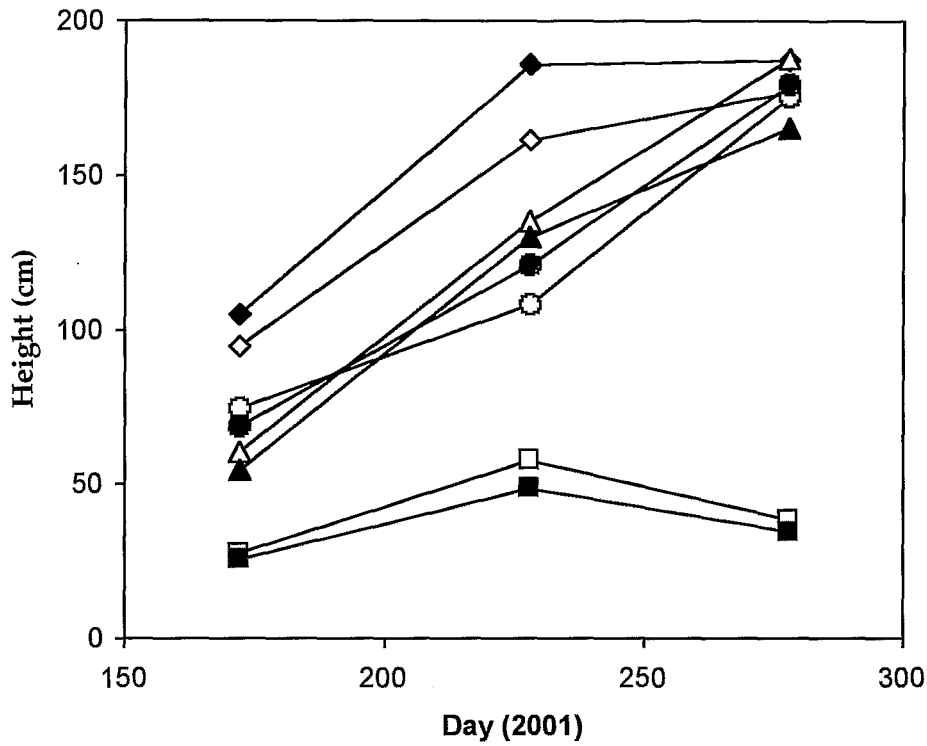

Figure 1. Average height of trees during production in containers on gravel (open points) and in mulch (solid points): ◆ *R. pseudoacacia*, ▲ *G. triacanthos*, ❑■ *G. dioicus*, ○● *C. canadensis*.

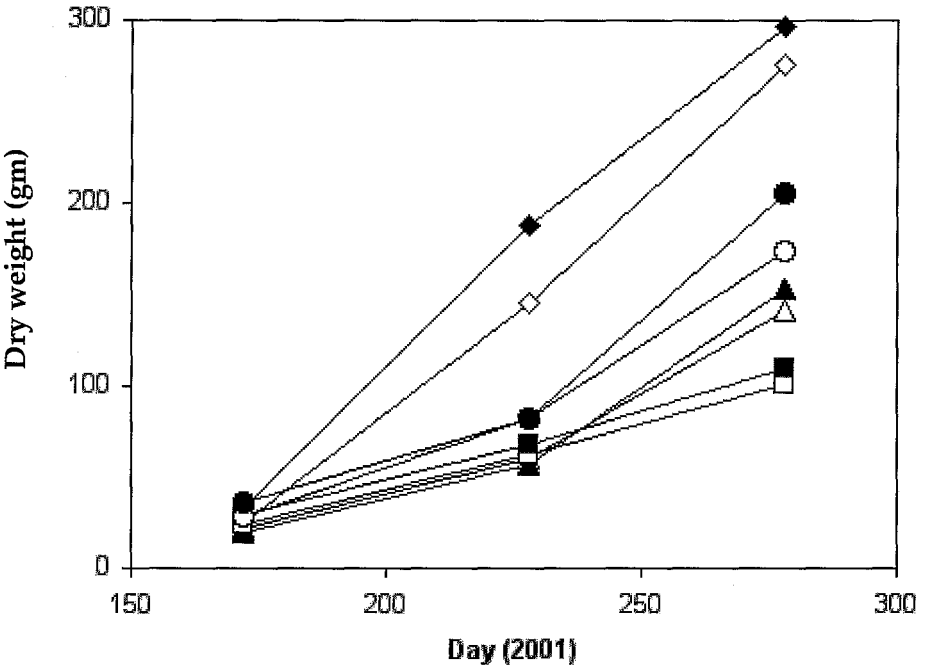

Figure 2. Average dry weight of roots of trees during production in containers on gravel (open points) and in mulch (solid points): ◆ *R. pseudoacacia,* ▲ *G. triacanthos,* ❑■ *G. dioicus,* ○● *C. canadensis.*

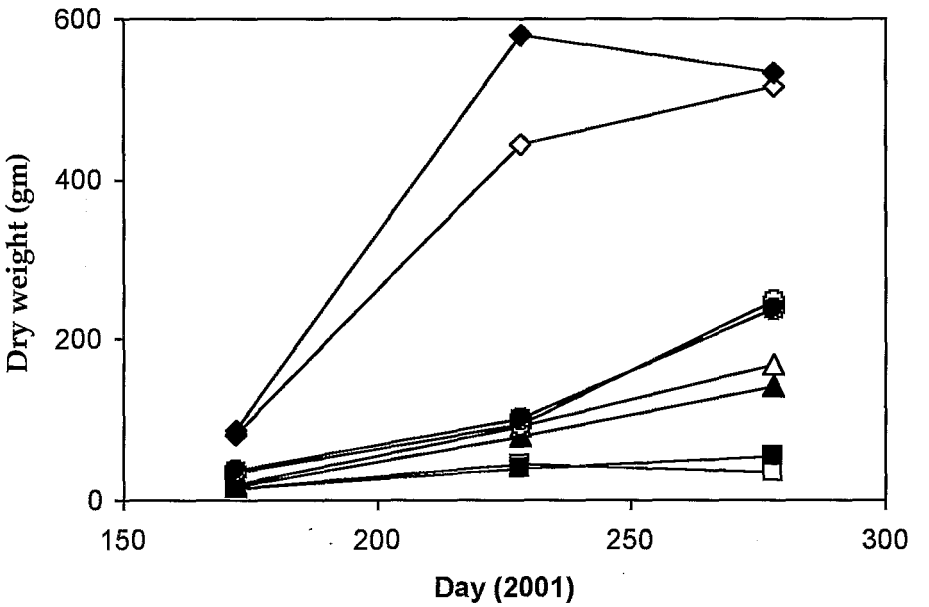

Figure 3. Average dry weight of shoots of trees during production in containers on gravel (open points) and in mulch (solid points): ◆ *R. pseudoacacia,* ▲ *G. triacanthos,* ❑■ *G. dioicus,* ○● *C. canadensis.*

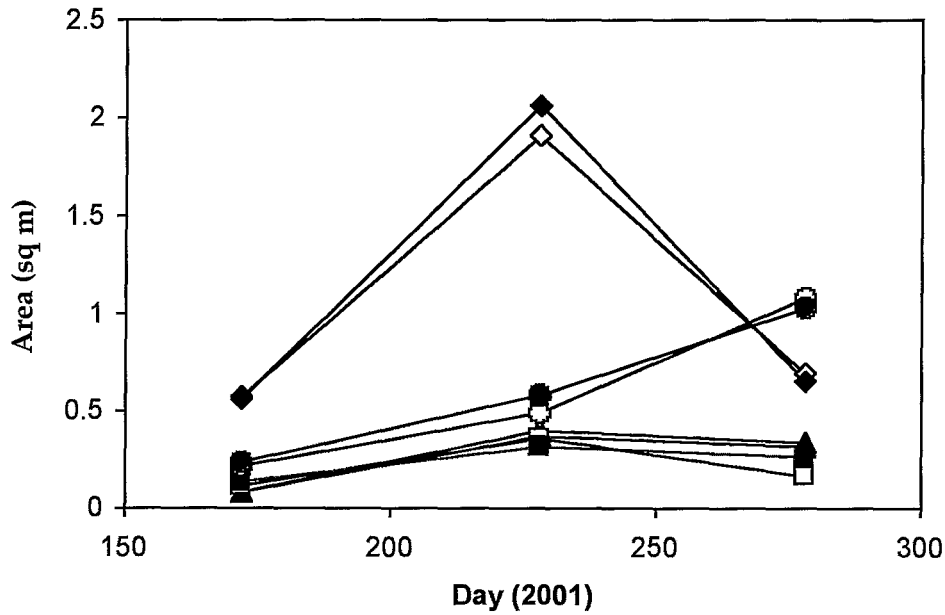

Figure 4. Average leaf area of trees during production in containers on gravel (open points) and in mulch (solid points): ◆ *R. pseudoacacia,* ▲ *G. triacanthos,* ❑■ *G. dioicus,* ○● *C. canadensis.*

the tree itself and in the container by comparing weight changes for foil-covered and uncovered containers. However, inspection of the data revealed that the foil cover was not nearly so effective when applied around a tree stem as for a pot of medium without a tree.

As an alternative, the slope of the regression of weight change on leaf area was used to estimate tree water consumption (Figure 5). Water consumption appeared to be lower for *C. canadensis* and *G. dioicus* than for *G. triacanthos* and *R. pseudoacacia.* Water consumption for trees in mulch was higher than on gravel for *R. pseudoacacia* and *C. canadensis.*

After planting out, *G. triacanthos* and *R. pseudoacacia* showed the largest increase in height, although *G. dioicus* showed the largest percentage increase (Table 2). *G. dioicus* and *R. pseudoacacia* from containers in mulch remained taller than those from gravel at the end of the first season in the field, but *C. canadensis* and *G. triacanthos* from gravel were taller than from mulch (Table 2).

Discussion

The temperature of the medium for containers on gravel was not as high as expected, and there was not much difference from the temperature of containers in mulch. However, these temperatures were recorded for the bulk medium, and they may have been higher on the sun-exposed side of containers on gravel. The occurrence of local heating is consistent with the greater evaporation from containers of medium on gravel, by comparison with containers in mulch. Local heating may also be the reason why root growth was lower in containers on gravel, and this effect was most noticeable for large plants whose roots were approaching the edge of the container.

Shoot growth (height and dry weight) was adversely affected by growing on gravel only in *R. pseudoacacia,* and leaf area seemed to be unaffected for any species.

The higher water use by the larger trees (*R. pseudoacacia* and *C. canadensis)* in mulch

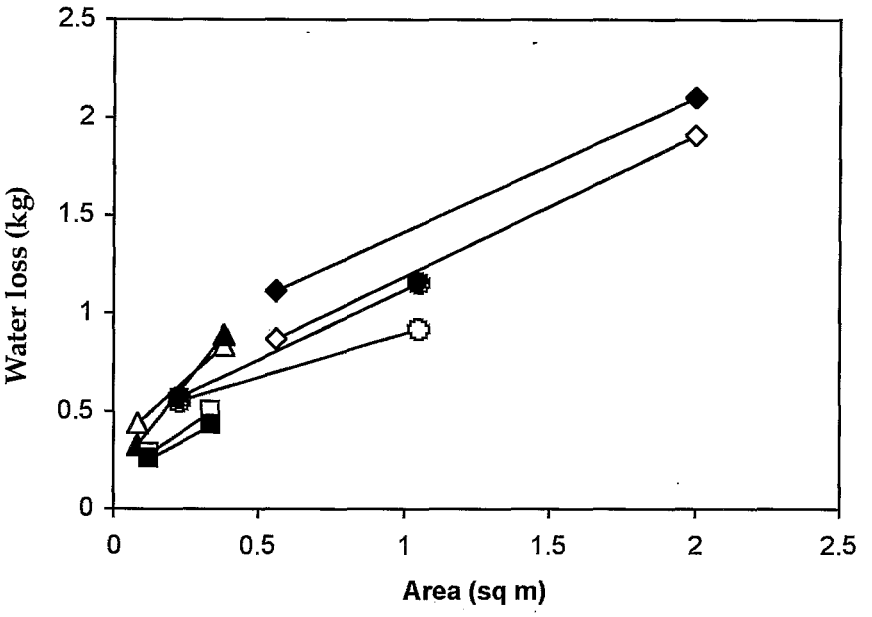

Figure 5. Water loss in 24 h by trees in containers on gravel (open points) and in mulch (solid points). The points represent the range of leaf areas recorded and the rates of water loss calculated from the regression of water loss on leaf area. Average potential evapotranspiration was 4.35 mm day-1.
◆ *R. pseudoacacia,* ▲ *G. triacanthos,* ❑■ *G. dioicus,* ○● *C. canadensis.*

Table 2. Average Height of Trees at Time of Transplanting (4/4/02) and After One Season's Growth (10/8/02).

Species	Production	Height (m)	
		4/4/02	10/8/02
Cercis canadensis	gravel	1.66	2.03
	mulch	1.51	1.80
Gleditsia triacanthos	gravel	1.90	2.46
	mulch	1.58	2.38
Gymnocladus dioicus	gravel	0.31	0.70
	mulch	0.42	0.94
Robinia pseudocacia	gravel	1.40	2.38
	mulch	1.76	2.64

than on gravel is consistent with their larger root systems and less temperature stress on the root system. Higher water use could also be associated with higher rates of photosynthesis since open stomata would permit influx of carbon dioxide as well as efflux of water vapor.

The only consistent result of this hypothetical enhancement of photosynthesis seems to have been an increase in root mass. This could include food reserves for future growth, but the limited data for growth after planting out do not show any consistent effect of production method on plant performance.

The rate of transpiration per unit of leaf area decreases as trees grow, so comparisons between species are most easily made at similar leaf areas. Lindsey and Bassuk (1991) showed a relationship between transpiration and leaf area based on averages for four tree species (Figure 6). *G. triacanthos* and *R. pseudoacacia* fit this relationship quite well, but *G. dioicus* and *C. canadensis* had lower rates of transpiration than predicted by the relationship (Figure 6).

The transpiration rate of a species helps to predict its water requirement under production conditions when water is not limiting. The transpiration rate may not be an indicator of water requirement in the landscape or ability to withstand drought. Levitt *et al.* (1995) showed that the drought-tolerant species, *Prosopis alba,* had a higher transpiration rate than the less tolerant *Quercus virginiana* under well-watered conditions.

In conclusion, root growth can be inhibited in containers exposed to the sun, especially

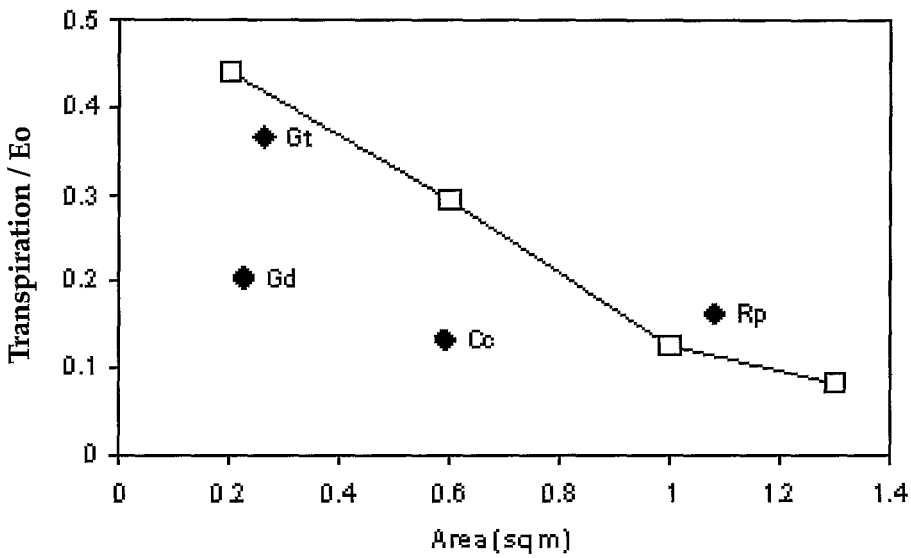

Figure 6. Ratio of average transpiration (from regression of water loss on leaf area) to potential evapotranspiration (Eo) in relation to average leaf area for trees in containers, compared to published data for other tree species. Cc *Cercis canadensis,* Gd *Gymnocladus dioicus,* Gt *Gleditsia triacanthos,* Rp *Robinia pseudoacacia,* ◆ Lindsey and Bassuk (1991) data.

when the root system grows to the edge of the container. It is not clear whether this has any lasting effect on growth after transplanting to the landscape. Honeylocust *(Gleditsia triacanthos)* and black locust *(Robinia pseudoacacia)* have similar water requirements to other shade trees studied by Lindsey and Bassuk (1991), but Kentucky coffee tree *(Gymnocladus dioicus)* and redbud *(Cercis canadensis)* had lower water requirements.

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The Effects of Sprayer Configuration on Efficacy for the Control of Scab on Crabapple

Charles R. Krause, Richard C. Derksen, Leona E. Horst, Randall Zondag, Ross D. Brazee, Michael G. Klein, and Michael E. Reding

Introduction

Production of woody environmental and floral crops represents more than 12% of American agricultural receipts. Unfortunately, fungus diseases like apple scab, caused by *Venturia ineaqualis,* result in millions of dollars of nursery crop losses each year. Effective fungicides must be applied to produce aesthetically pleasing plants.

New guidelines for registering, using, and maintaining pesticides through the U.S. Environmental Protection Agency were created by the Food Quality Protection Act of 1996 (FQPA-96) and require information on how pesticides are used.

Research is crucial on fungicide spray methods related to efficacy. Assessment in past studies involved only macroscopic disease ratings. More complete knowledge of the fate and behavior of fungicides will lead to reduced pesticide use with less off-target deposition.

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The purposes of this study were to directly evaluate and correlate the fungicide coverage with the amount of apple scab disease; to assess the effects of sprayer/nozzle type on efficacy and disease control; and to assess any drift or non-target deposition from two types of sprayers in nurseries.

Materials and Methods

Plant Materials

Dedicated nursery plots consisting of six crabapple replication rows with four treatments per replication each were planted (Figure 1). A replication consisted of seven, two-year-old crabapple whips of each cultivar — *Malus* spp. cv. Candied Apple and cv. Red Jade — for a total of 14 trees per replication. Barrier rows were also planted between crabapple treatment rows in all production nurseries.

Treatments

Treatments were randomized in each of six rows as follows:

- Axial flow, airblast sprayer with conventional high-volume nozzle delivering 300 psi, traveling at 4 mph.

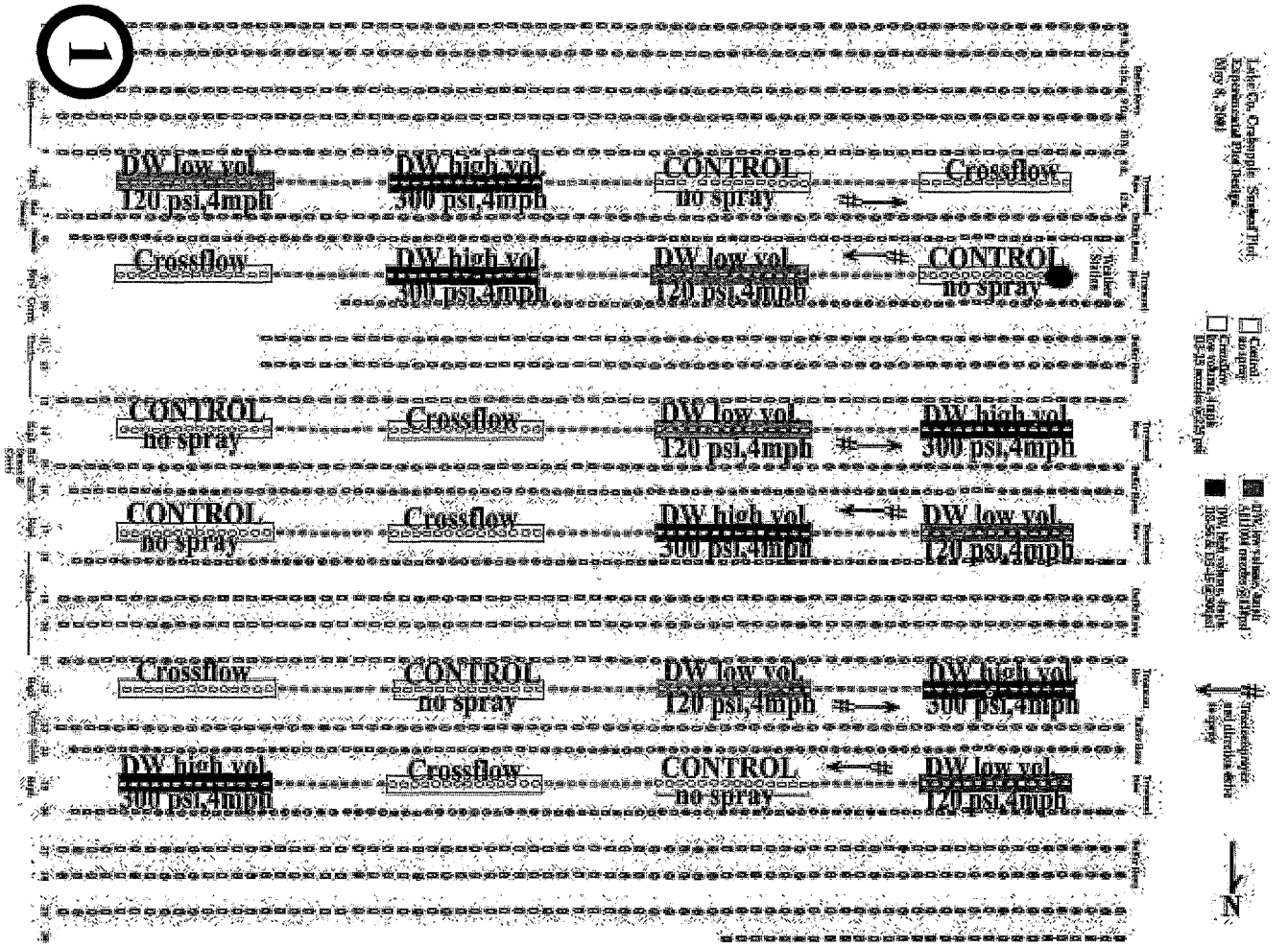

Figure 1. Dedicated nursery plots consisting of six crabapple replication rows with four treatments per replication each were planted.

- Axial flow, airblast sprayer with air induction nozzles delivering 120 psi traveling at 4 mph.
- Experimental air curtain sprayer or crossflow fan sprayer with air induction nozzles delivering 120 psi at 4 mph.
- Unsprayed control.

Spray treatments were begun in May 2001. Figure 2 shows the axial flow, airblast sprayer delivering a treatment to one of the replications.

Bioassay and Leaf Analysis

Sample holders used for mounting samples for scanning electron microscopy (SEM) called stubs, each with conductive, adhesive specimen mounts (Ted Pella, Tustin, Calif.), were mounted in trees before each treatment. Leaves and stubs were collected from each treatment after each spray for bioassay and electron beam analysis (EBA), a combination of SEM and energy dispersive X-ray analysis (EDXA). Leaves from each treatment were collected after each spray and freshly mounted on stubs using adhesive specimen mounts.

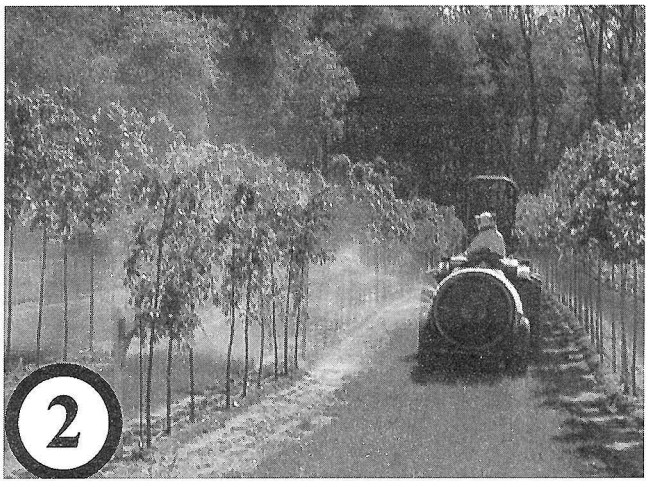

Figure 2. The axial flow, airblast sprayer delivers a treatment to one of the replications.

A cold field emission scanning electron microscope (CFESEM) and a variable pressure scanning electron microscope (VPSEM), both equipped with EDXA, located at the Molecular and Cellular Imaging Center at The Ohio State University's Ohio Agricultural Research and Development Center's (OSU/OARDC), Wooster campus, were used for EBA. Electron beam analysis permitted direct visualization and identification of the pathogens, morphologically, and chemical characterization of any fungicide present.

The fungicide used in this study was Mankocide, a combination of $Cu(OH)_2$ and mancozeb that permitted EBA identification based on the presence of Cu, MN, and Zn in the molecule.

Disease Evaluation

Disease incidence ratings based on a modified Horsfall-Barrett Scale were taken each month during spray treatments.

Weather Stations

A portable meteorological station (Campbell Scientific Instruments) was installed within the experimental plot to remotely monitor air temperature, leaf wetness, relative humidity, wind speed and direction, rainfall, and solar radiation, according to guidelines of the United States National Oceanic and Atmospheric Administration.

Results and Discussion

During the 2002 growing season, little apple scab disease was observed macroscopically. Free moisture on leaf surfaces was lacking, as recorded by the meteorological station, indicating conditions were not conducive for disease development.

Electron beam analysis of leaf samples observed during the early portion of the year (2002) confirmed the lack of the fungal pathogen. When limited disease (< 5% to 10%) occurred on both cultivars in June 2002, EBA confirmed the presence of the pathogen. While fungicide coverage was measured with EBA, low disease pressure did not permit quantifying differences in efficacy.

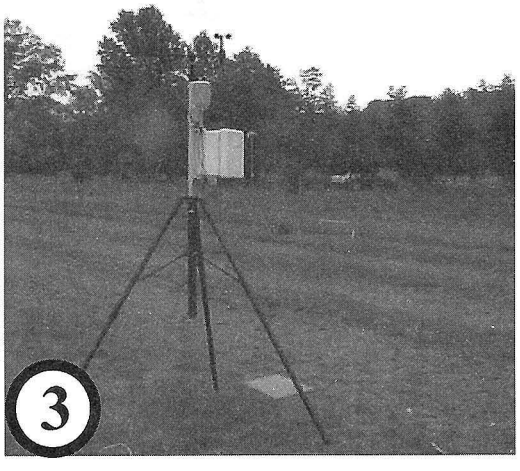

Figure 3. A portable meteorological station was installed within the experimental plot.

This project involved development of experimental methods, including the use of remote leaf wetness sensors, essential for studies of apple scab. The use of fungicides as tracers for EBA was developed as part of the analytical protocol for studying spray efficacy. Specimen handling technology was developed for subsequent studies. Techniques developed in this study will be adapted for assessment of other disease and pest management problems. Improved knowledge of the basis of efficacy and coverage will improve grower profitability and protect farm workers, consumers, and the environment.

Acknowledgments

This research is sponsored in part through a grant from the Horticultural Research Institute, American Nursery and Landscape Association, Washington, D.C. The U.S. Department of Agriculture, Agricultural Research Service (ARS), Application Technology Unit also expresses its appreciation to Robert Lyons, President, Sunleaf Nursery, Madison, Ohio, and Colin Ruckle, President, Warner Kingwood Nursery, Willoughby Hills, Ohio, for the use of their respective nurseries during this long-term project.

The authors also wish to thank Rolly Hart for applying spray; Jay Daley and Ray Headly, Sunleaf Nursery; and Mac Fulton, Warner Kingwood Nursery, for their cooperation during this investigation.

Disclaimer

Names are necessary to report factually on available data; however, the U.S. Department of Agriculture, Agricultural Research Service, and The Ohio State University neither guarantee nor warrant the standard of a product. Further, the use of the name by USDA or OSU implies no approval of the product to the exclusion of others that may be suitable. This article may be freely reprinted with customary crediting of the source.

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Update on Honeylocust Knot

Pierluigi Bonello, Maria Bellizzi, and Harry A. J. Hoitink

Introduction

Honeylocust (*Gleditsia triacanthos*) is native to the east-central United States and is an important nursery and ornamental plant. Growers typically produce plants of various sizes. Trees priced at $150 to $200 each (two- inch caliper) are commonly marketed at the wholesale level. Honeylocusts are very common in the urban landscape due to their pleasing form, light shade, hardiness, and tolerance to drought and salinity (Blair, 1990).

Although this tree species is susceptible to attacks and damage by multiple insect pests (e.g., plant bugs, spider mites, flatheaded borers, mimosa webworms, etc.), diseases have historically been a minor problem in the landscape and nursery (Blair, 1990).

Canker caused by *Thyronectria austro-americana* can occasionally cause mortality losses. Furthermore, aging honeylocusts become more susceptible with time to root rot and decay fungi such as *Ganoderma lucidum* which can kill the tree over a number of years. Unlike many other hardwoods, leaf diseases usually are not important (Hepting, 1971).

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Chronology

In the summer of 2000, Dr. Hannah Mathers, of The Ohio State University's Department of Horticulture and Crop Science, reported what appeared to be a new disease of honeylocusts to the authors. The condition was discovered at a nursery near Cincinnati, Ohio. By the summer of 2001, the disease had resulted in total mortality of entire rows of two-inch caliper 'Skyline' honeylocusts.

Another nursery in Michigan noticed a similar condition in 2000, this time on 'Shademaster' honeylocusts. The syndrome reappeared there again in 2001 and led to the mortality of several rows of trees.

At both locations, the disease reappeared in 2002 and caused severe mortality, again concentrated in specific rows or groups of trees.

The nursery in southwestern Ohio reported an apparent link between hand pruning conducted in the course of normal horticultural care operations and the appearance of symptoms in both seasons. That nursery sustained a loss of more than $130,000 in wholesale value over the course of two years.

Current Distribution

In 2002, we received an additional report in midsummer of a similar condition occurring on some urban honeylocusts in the Cleveland area. Throughout this past sum-

mer, more reports began coming in from adjoining states. There are now records of the disease from nurseries and landscapes in Ohio, Illinois, Iowa, Kentucky, Maryland, and Michigan.

Symptomatology

Initial symptoms observed in nurseries include the development of shepherd's crooks on terminal shoots (Figure 1) and wilt-like leaflet cupping (Figure 2). The condition then progresses to yellowing of the canopy, defoliation, and death of the entire tree.

Concurrent with the appearance of the shepherd's crooks and wilting symptoms, the terminal shoots often acquire a burnt-like appearance reminiscent of fire blight, except that the shoots defoliate quickly, giving a dieback-like symptom (Figure 3).

The most characteristic symptom of the disease, and the one that suggested the current name, is the appearance of knots, ranging in size from about 5 mm to more than 5 cm in diameter (1/4" to more than 2") on the nodes of twigs and branches. These always appear first as swellings at the base of branches on the main stem, where they can reach a considerable size.

In the early stages and on smaller branches, these galls often appear as two swellings at the nodes, one on each side of the lateral twig or compound leaf (Figure 4). In advanced stages, these swellings can become quite irregularly shaped and deformed (Figure 5).

Occasionally, the swelled area continues down the stem or trunk of the tree to the next branch. This galling activity suggests that the condition alters the hormonal balance of the host, particularly that of indoleacetic acid (IAA = auxin).

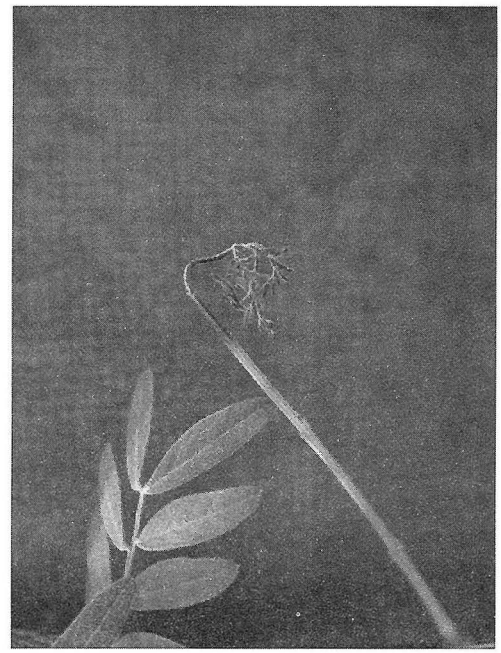

Figure 1. A typical shepherd's crook on a shoot tip.

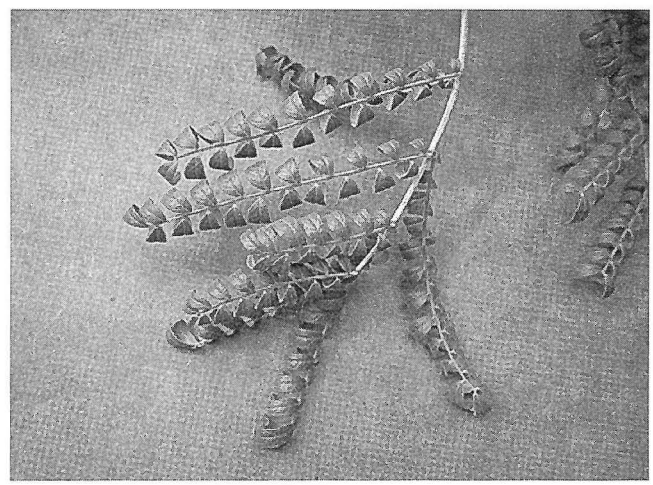

Figure 2. "Cupping" of leaflets, a wilt-like symptom.

Current Research

We suspect that this disease is not of an abiotic origin, such as improper cultural practices, adverse soil textural and structural properties, pH, application of herbicides and pesticides, unusual climatic events, etc., because the disease has manifested itself under an extremely varied set of conditions in dif-

Figure 3. Dieback symptoms.

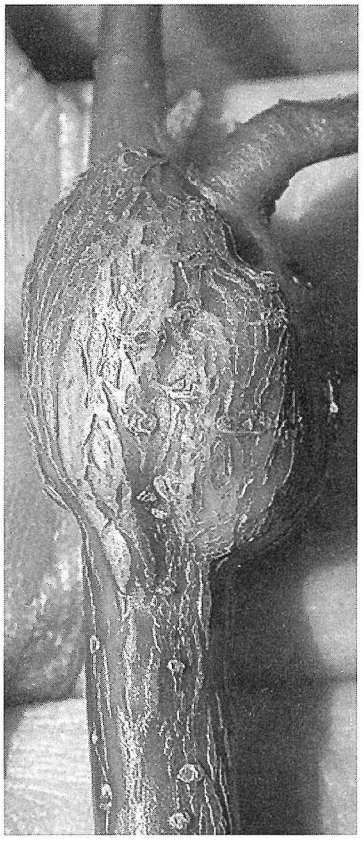

Figure 4. A characteristic double knot on a young shoot near the petiole of a compound leaf.

ferent nurseries and landscape situations across a number of states characterized by different climatic conditions and soil types.

Although several insects can cause galling on many different plants, no evidence of primary insect activity was detected on the diseased honeylocusts. We have observed colonization of older soft tissue galls by larvae but this has been interpreted as a secondary phenomenon that is part of the natural decay process associated with these galls.

Several aspects of the disease suggest that it may be caused by a bacterium. First, similar diseases of woody plants, such as ash trees in Europe and olive, oleander, privet, and jasmine in the United States and elsewhere, are caused by various pathovars of the bacterium *Pseudomonas savastanoi* (Alvarez *et al.* 1998; Azad and Cooksey, 1995). *P. savastanoi* is a known producer of IAA, and the knotting it produces in susceptible trees has been attributed to this trait.

Second, the disease seems to be correlated with pruning activity in nurseries, an aspect reminiscent of one of the main spreading

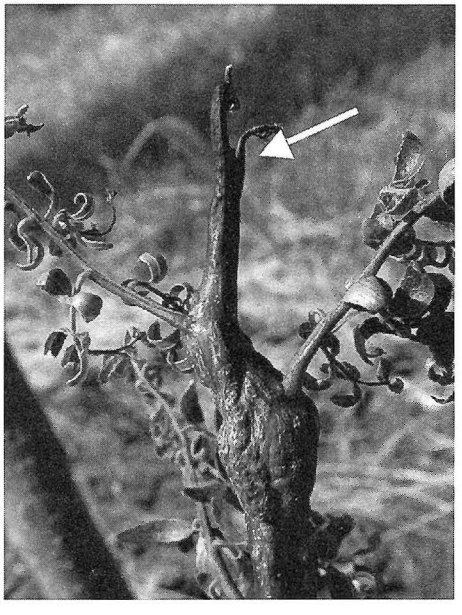

Figure 5. Advanced stage of coalescing knots resulting in gross deformity near the shoot tip. Note the burnt-like appearance of the tip.

routes for fire blight, a disease caused by a different bacterium, *Erwinia amylovora.*

Third, the Cincinnati nursery treated some of its trees in 2002 with copper-containing pesticides and reported that symptoms did not develop on the treated trees. Copper-containing pesticides can be effective against bacterial plant pathogens that invade aboveground plant parts.

Based on this information, we embarked on a diagnostic project during the summer of 2002. Initially, we attempted to determine whether *P. savastanoi* was involved, perhaps as a new pathovar. However, repeated isolation attempts from samples originating in Ohio, Maryland, and Michigan so far have failed to yield strains of that pathogen.

Nevertheless, several unknown and yet uncharacterized strains possessing clear pathogenic properties have been isolated from knots and will undergo proof of pathogenicity tests in early spring of 2003, when the tree hosts are likely to be more sensitive to the pathogen, given their phenological status (resumed active growth, hormonal activity, nutrient mobilization, etc.). It is possible that a new pathogen, or a new pathovar of an existing pathogen, is involved. Considerably more work is necessary before this question can be answered.

While we suspect that the disease is of bacterial origin, we are keeping other possibilities open and will conduct additional electron microscopic studies to determine if other microbes that could, in theory, cause similar symptoms might be involved, either as primary or contributing agents. These possible pathogens are phytoplasmas (a type of simplified bacterium formerly known as mycoplasma-like organisms, or MLOs) and viruses. Initial tests for these microorganisms have been negative, however. No evidence of fungal activity has been found so far.

Outlook

Pierluigi Bonello's laboratory, in collaboration with Dave Coplin's plant bacteriology lab in the Department of Plant Pathology at Ohio State, has become the center of investigation for this new, potentially very damaging disease.

With ongoing collaboration from the nursery industry, it should be possible to identify the causal agent of this disorder, which is the essential step in pursuing the development of rational control strategies for the nursery and landscape industries.

Acknowledgments

The authors would like to thank Carol Musselman and Michael Scott for their technical help. Much of this investigation could not have taken place without the assistance of Dave Coplin and his graduate student, Massimo Merighi, whom we would also like to thank for their contributions.

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Control of Phytophthora and Other Major Diseases of Ericaceous Plants

Harry A. J. Hoitink, Steven T. Nameth, and James C. Locke

Introduction

Phytophthora diseases affect many nursery crops. They can be divided into dieback diseases that involve blights of leaves and shoots, and root and crown rots. Many nursery crops are susceptible. Plants in the family Ericaceae (rhododendrons, azaleas, etc.) are among the most susceptible.

Phytophthora diseases, such as root rot of Fraser fir and of *Chamaecyparis lawsonii*, apparently are caused by a single species of the *Phytophthora* fungus. Others, such as Phytophthora root rot of rhododendron, may be caused by any of eight *Phytophthora* species.

Three different species of *Phytophthora* have been isolated from the same infected rhododendron plant, demonstrating rhododendron's high level of susceptibility to this root-rot disease. Azalea and *Pieris*, like rhododendron, are susceptible to both root rot and dieback.

Lilac is another crop highly susceptible to *Phytophthora* root rot and dieback. *Potentilla* is susceptible to dieback only, and *Taxus* and junipers to root rot only. Crabapples and several other rosaceous plants are also susceptible to collar rots.

In the 1960s and early 1970s, root rots were the most common diseases of nursery plants. They were especially severe on plants in poorly drained soils or in peat mixes. Bark-amended media, now used widely for disease control in the industry, helped suppress root rots.

After reducing the threat of root rot through the use of bark mixes, nurserymen were able to increase fertility levels and shorten production cycles. After increasing fertility, Phytophthora dieback (foliar and stem diseases) became more important than root rots on plants grown in containers.

Subsequent research showed that the nitrogen concentration in the new growth of rhododendron plants is directly related to Phytophthora dieback susceptibility. This relationship probably applies to other crops as well. For example, plants of *Rhododendron* cv. Roseum Elegans with a nitrogen concentration greater than 2.0% in young foliage (last flush) are very susceptible. Lesions on

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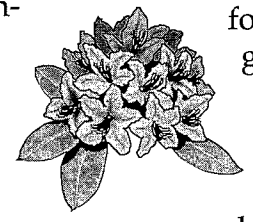
new growth of high-nitrogen plants may extend down to the crown in 10 days or less. The same infection on a low-nitrogen plant (1.2% N in new growth) remains small (pin head in size) and may not be detected.



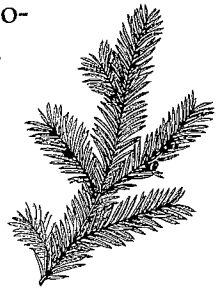
Native rhododendrons growing in unfertilized natural settings have such low nitrogen levels that they produce only one flush of growth per year. The disease has not been observed on wild plants, even though the pathogen is very widespread in distribution.

The best way to control Phytophthora dieback in the landscape is to maintain moderate nitrogen fertility levels. For nursery production in containers, this practice is not practical because young plants maintained under lower fertility levels grow too slowly to permit economic production. In field-grown rhododendrons, dieback is less severe. In part, this is due to lower fertility levels maintained in the field.

The Life Cycle of Phytophthora Diseases

Phytophthora species associated with woody plants generally over-winter in infected plants or in decaying infested plant debris in the soil or container medium. They generally do not survive after infested crop residues have decomposed in soil. Most do not survive extremely cold winters in crop residue.

An exception is *Phytophthora citrophthora,* which causes a severe crown rot and shoot blight problem on *Pieris japonica.* It also causes dieback on rhododendron and root rot of *Taxus.* This species can survive in infested tissues on the surface of the soil even in winters with -25ºF temperatures.



Irrigation water collected from streams or irrigation ponds typically is contaminated with *Phytophthora* spp. Water used for greenhouse crops should be disinfested but that is not practical for the large volumes of water used on containers. Slow sand filters have been developed recently that are very effective for treatment of irrigation water for greenhouse crops.

Phytophthora spores germinate in water droplets or in a film of water. Spores may be splashed with water droplets onto foliage or be moved in running water in the soil or on the soil surface. Some spores known as zoospores are motile and swim towards root tips or stomata on leaves where they cause infections. Leaves must be wet for at least two hours for infections to be successful. Dry leaves do not become infected even when the humidity is high.

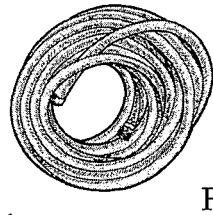
Disease Prevention During Propagation

Propagation benches must be raised and must provide excellent drainage. If a second crop is to be grown in the same medium, it should be a cultivar that roots quickly and is not susceptible to the same diseases as the first crop. The floor and walks between beds should be free of puddles and weeds. Proper management of irrigation water is a key to management of these diseases. **Puddling and flooding should be avoided at all cost to reduce sporulation and spreading of the pathogen.**

Before new propagation media are placed in the greenhouse, the headhouse, greenhouse, and benches should be brushed free of all organic debris and old propagation media. Infected residues need to be removed from container production areas between crops, if at all possible.

All cleaned surfaces should be washed with sanitizing agents such as Physan 20 or Greenshield (PT-2000) or other similar ma-

terials. Propagating knives and other tools should be dipped from time to time when harvesting cuttings. Watering hoses must be kept off the floor to reduce introduction of pathogen inoculum onto the bench with the hose.



A common propagation medium for Ericaceae (particularly azalea) is a 1:1 mixture of fibrous light Sphagnum peat and coarse Perlite. Mixtures of aged pine bark and fibrous peat (6:4) are used widely for rhododendron cultivars. The percent air-filled pore space in rooting media should be as high as possible (25 to 35%). In a poorly aerated propagation medium (15 to 20%), large calluses are formed on rhododendron cuttings and root initiation is delayed.

If fine, rather than fibrous, peat is used, the air-filled pore space often is below 20%. This results in less rooting and more disease caused by stress pathogens. This is a very common problem encountered in propagation. Always use fibrous peat in propagation media!

Cuttings should be taken from plant parts free of soil, and stock plants must be treated with fungicides as described later.

Propagation Fungicide Schedule

The fungicide schedule used during propagation must be adjusted to the needs of the crop. On rhododendrons and azaleas, *Phytophthora, Cylindrocladium, Botryosphaeria,* and *Rhizoctonia* are the most important pathogens in Ohio. *Fusarium, Phomopsis,* and *Pestalotia* are minor pathogens but need to be controlled also to avoid infection of cut stem surfaces on cuttings. *Botrytis* also can cause problems, and Cercospora leafspot may be present as well. The surface of plants during propagation is continuously wet; therefore, fungicide treatments often have short-term effects.

To obtain effective control of this wide range of pathogens under these high disease-pressure conditions, broad spectrum fungicides must be applied on a preventive basis. Some of the effective fungicides for Pythium and Phytophthora diseases include: Subdue MAXX, Chipco Aliette, Banrot, and Truban. Fungicides such as Domain, Topsin-M, Cleary's 3336 (thiophanate methyl), Banrot, and Terraclor are used for *Botryosphaeria, Rhizoctonia,* and *Cylindrocladium.*

Terraguard is an excellent fungicide for control of Thielaviopsis black root rot. Mancozeb (e.g., Dithane or Fore), Stature, chlorothalonil (Daconil Ultrex), Chipco 26019 and copper fungicides such as Kocide 2000, Champ DP, Champion WP, Camelot, Phyton 27, and Bordeaux mixture are excellent broad spectrum fungicides for control of leaf spots. These fungicides need to be applied weekly during mist propagation on crops such as rhododendron. Be sure to follow all instructions on the label. The best procedure is to alternate fungicides with different modes of action.

Control of Dieback

One principal objective of nursery production is to keep the cropping cycle as short as possible by providing high-fertility conditions. Therefore, plants in containers are maintained under conditions that make them highly prone to development of Phytophthora dieback throughout high-temperature growing seasons. This places more importance on disease management in nurseries through the use of fungicides, appropriate irrigation methods, and disease-suppressive container media. In arid climates, plants dry quickly enough after irrigation to avoid infection by *Phytophthora* spp. on the foliage.

Proper management of irrigation is basic to disease management, especially for plants

produced in containers. Irrigation should be applied early in the day so that foliage dries quickly. Trickle irrigation is preferred for crops highly susceptible to Phytophthora dieback, because it keeps the foliage dry and avoids splash dispersal of pathogens. Flood irrigation should not be used because it can severely enhance the spread of Phytophthora root-rot pathogens in particular. Unfortunately, Ohio summers often are humid and high in temperature. Therefore, fungicide sprays may have to be applied frequently.

Phytophthora dieback and root-rot epidemics generally occur from early summer to early fall and mostly on container-grown stock when temperatures range from 75 to 95ºF, particularly when the relative humidity is high. In some parts of the world, low-temperature Phytophthora diseases are active during mild winters as well. The authors have not isolated such *Phytophthora* spp. in Ohio. Sprays generally need to be applied thoroughly to all above-ground plant parts because all leaves, buds, and meristematic tissues protruding through resistant bark tissues on branches are susceptible.

Examples of fungicides that can provide effective control of dieback are mancozeb (e.g., Dithane M-45), Stature, chlorothalonil (e.g., Daconil Ultrex), and copper fungicides such as Kocide 2000, Champ DP, Champion WP, Camelot, Phyton 27, and Bordeaux mixture, in addition to fosetyl-Al (Chipco Aliette) and mefenoxam (Subdue MAXX). Subdue MAXX and Chipco Aliette are narrow-spectrum systemic fungicides. They should be applied once per month, but follow the label. Depending upon irrigation method, temperature, and rainfall, some fungicides may have to be applied weekly or even more frequently. Again follow labels precisely!

Other Dieback Diseases

During the spring, when covers are removed from houses, winter injury and other stresses, such as browning of leaves, become evident due to inadequate spacing of plants. Plants also break dormancy at that time, and *Botryosphaeria dothidea* becomes active. *B. dothidea* is a serious dieback pathogen that causes symptoms very similar to Phytophthora dieback. It is very difficult to control. The only totally effective control procedure is to avoid stress.

Botryosphaeria also infects plants affected by frost injury or sun scald. During the summer, it becomes active on plants severely affected by mite infestations. During propagation of cuttings, it becomes active after rooting, as new stem tissues develop. At this stage, spread of the disease can be controlled.

Inoculum of *Botryosphaeria* is present in cankers of many trees and shrubs. It spreads as airborne spores early in the spring. Chemical control is effective only if used on a preventive basis. The most active fungicides are the benzimidazoles (e.g., Domain, Topsin-M, Cleary's 3336-F). Sprays must be applied immediately after the damage has occurred. Plants such as rhododendron and *Pieris* do not recover once dieback symptoms have developed. Pruning of affected stems often does not prevent further decline.

Control of Root Rots

Cultural practices are very important for control of root rots. The most important factors are the container medium, the irrigation system (irrigation and pond systems, container base, etc.), and fungicide drenches.

Cultural Practices

The most widely used *Phytophthora*-suppressive container media are those amended with tree barks. Both composted

hardwood and pine barks suppress root rot caused by *Phytophthora cinnamomi*. Part of this effect is due to the improved aeration and drainage properties as compared to peat-sand container media. The percent air-filled pore space after saturation and drainage must be 25% or higher. The percolation rate must be greater than 0.5 inch per minute. Puddling on the surface of media must be avoided because it clearly enhances root rot. Containers should never be placed on plastic film because this allows *Phytophthora* to spread from pot to pot in puddles on the plastic.

Composted rice hulls, sewage sludges, cow manures, etc., also can be added to mixes. Most of these materials contain fine particles and therefore only small amounts can be added to mixes to avoid drainage problems. Composted sewage sludges and manures also may contain high levels of nutrients, and this is an advantage if the right amounts are used. Generally, it is best to incorporate 5 to 10% by volume of these materials in mixes containing 60% or more aged pine bark. These mixes supply adequate amounts of trace elements for one year after potting.

The container medium formulations presented here are examples of those that naturally suppress Phytophthora root rots. The quantity of lime added to the three media listed here varies with the quality of the irrigation water available at nurseries. It typically ranges from 3 to 8 lbs. per cubic yard of mix to maintain the pH within the range of 5.3 to 6.3. Micronutrients do not have to be added to mixes if composted biosolids or manures are included in the mix.

None of the control procedures described here are fully effective without the use of strict sanitation procedures during propagation and a proper layout in the container area. The base on which containers are placed should consist of gravel, stone, or well-drained sand. Covering such a base with the "plastic screen" mulches that control weeds but do not allow puddles to form is ideal. This is because propagules of pathogens present in abscised leaves, as well as pruning residues and other forms of crop infested residues, can be removed easily from this base before the next crop is introduced.

Water draining away from crops should be recycled to a primary settling pond. From there it should drain to a second pond from which irrigation water is pumped. Ponds should be cleaned out occasionally so that ample depth for settling remains. This approach is not totally effective, however. *Phytophthora* inoculum is disseminated in most irrigation systems used at nurseries. To control *Phytophthora* inoculum that is disseminated in these systems, nurseries can install a slow-sand filtration system for water that is used in the greenhouse production area of nurseries.

Some nurseries store water in two separate pond systems, each used for a particular container area. The second pond contains runoff from the first production area. The greatest potential for pathogen re-circulation, therefore, is associated with the second system. Crops that are more resistant to Phytophthora root rots and salinity should be irrigated with water draining from the production area where susceptible plants are produced. It is important to monitor chlorides and salinity in water. They specifically increase root rot and can break down resistance in plants to these diseases.

Root Rot Fungicides

Chipco Aliette and Subdue MAXX are examples of fungicides that are very effective when applied as drench treatments for control of Phytophthora root rots. Follow the label for each crop.

Resistant Varieties

A large number of rhododendrons and azaleas have been screened for resistance to root rot and dieback. Varieties and species somewhat resistant to root rot were found. However, this resistance can be broken down under conditions of severe drought, high salinity, or other stress conditions. Furthermore, the most popular varieties are highly susceptible. Resistance to these diseases therefore typically is not a realistic control option.

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Is Your Landscape Mulch Going Up In Smoke?

Larry G. Steward, T. Davis Sydnor, and Bert Bishop

Introduction

Mulches are commonly applied after shrubs and ground covers are planted in the landscape. Mulches are chosen for a variety of reasons including aesthetic appeal, color, price, organic content, nutrient content, reduction in weed competition, and dust abatement.

Many commercial and public facilities no longer allow smoking inside the facility as a result of today's laws and policies. Cigarette and cigar smokers often discard lighted smoking material, including lighted matches, into the landscaped areas as they enter the building. This results in the potential for mulch ignition. As people move from smoking areas outside the building to areas within, discarded cigarettes smolder and may set the mulch on fire. Mulch fires, besides destroying the landscape plant material, may place frame construction buildings at risk.

The risk of a mulch fire is, perhaps, more common than one might expect. The Ohio State University Agricultural Technical Institute (ATI) campus in Wooster, Ohio, had an incident in fall 2000 where smoldering mulch indicated a subsurface mulch fire (Garrod, 2000). In Columbus, Ohio, a mulch fire was credited with severely damaging a building (Narciso, 1997).

Scioto Dublin High School in Dublin, Ohio, was closed as a result of a mulch fire that contaminated the air handling system in the building (Sternberg, 1997). An improperly discarded cigarette ignited the landscape mulch and then spread into the crawl space beneath the structure, damaging a Brookhaven National Laboratory structure (Levesque, 2001).

Problems such as these have become enough of a nuisance at the University of Maryland for their Environmental and Safety Department to develop a *Mulch Fire Standard Operating Procedure* (Anonymous, 2002a).

Materials and Methods

In order to be able to study the ignition potential of materials for mulches to be used in the landscaping process, the researchers selected 13 mulches commonly used and recommended for landscape operations (Sydnor, 1994; Rose and Smith,1996; Williams, 1996; Relf, 1997). These mulches were then evaluated for their ease of ignition under natural field conditions.

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Four replicates of the 13 mulches were arranged in a randomized block pattern. There was no blocking effect in any of the tests; thus, the data was analyzed as a completely random design.

The mulches selected for study included the following organic materials — shredded pine bark, shredded hardwood, shredded cypress, composted yard waste, 1/2-inch pine bark nuggets, pine straw (needles), dyed recycled wooden pallets, cocoa shells, oat straw, and mixed grass sod. The following inorganic materials were also included — brick chips and ground rubber tire mulches. Materials were assumed to be equally ignitable.

Aluminum edging strips were used to divide the test areas into circular areas of $0.84m^2$ ($1\ yd^2$) each. The aluminum edging strips were used to prevent mulch from igniting adjacent blocks and contaminating adjacent areas with other mulching materials. Additionally, turf was employed to further separate the test areas.

Mulch depth for each sample was the recommended maximum landscape depth of four inches (Sydnor, 1994; Appleton and French, 1995).

The evaluation was done in an open sod-covered area at Ohio State's ATI facility at Apple Creek, Ohio, so that natural conditions were representative of typical landscape conditions in Ohio. The purpose of this test was to demonstrate what could happen under natural environmental conditions. Further, the mulches were not treated with any fireproofing material (Hickman, 1996).

Mulches were applied to the test blocks in the fall of 2000 from bags or bulk piles. The mulches were allowed to settle for two weeks prior to initiating ignition tests. The mulch materials were subjected to ignition by cigarettes, matches, and a propane torch.

For the cigarette ignition tests, student volunteers were asked to ignite and then discard three lighted filter cigarettes on the surface of each of the four replicates of each mulch sample. The cigarettes and mulches were monitored for 20 minutes to determine if the mulch material ignited. The period of time was measured in seconds from application of the burning cigarettes to ignition of the mulching material. Flames in excess of 15 cm (6 in.) high were noted and then extinguished.

The cigarette ignition trial was conducted twice. The first test was conducted on November 2, 2000, 14 days after the mulch was applied. Weather conditions on that day were relatively calm with temperatures near 50°F. There had been one day since any measurable rain, and the average relative humidity was 68% (Anonymous, 2002b). Wind was reasonably calm, and the test was done in the late afternoon.

The second cigarette ignition test was done on July 27, 2001, to determine if there is any change in the ease of ignition due to natural weathering. Air temperature was 65°F at the time of the test. Wind was reasonably calm on this date also, and the test was done in the late afternoon. The relative humidity averaged 54%. It had been one day since any measurable amount of rain (Anonymous, 2002b).

Match ignition tests were conducted on April 26, 2001. Three wooden matches were lit and thrown onto the surface of the four replicates of each mulch. The time until an active flame occurred in the mulch or until the matches burned out was recorded. The conditions at the time (mid-day) were clear, 55°F, and a light breeze (5 mph gusting to 7 mph). It had been two days since any measurable rainfall. Relative humidity was an average of 58% (Anonymous, 2002b).

The propane torch ignition tests of the mulches were done on November 2, 2001. The flame of the propane torch was in con-

tact with the surface of each of the four replicates of the mulch samples for 15 seconds. The torch flame was then removed, and the time until flames or coals extinguished was recorded up to 60 seconds. Residual flames or embers were mechanically extinguished after 60 seconds.

Ease of ignition following the torch ignition tests was rated on a scale from 1 to 7 as follows:

1 = No flame or embers @ 15 seconds.

2 = Flame @ 15 sec. but no embers @ 30 sec.

3 = Flame @ 15 sec. and embers @ 30 sec. but no embers @ 60 sec.

4 = Flame @ 30 sec. but no embers @ 60 sec.

5 = Flame @ 15 sec. and embers @ 60 sec. with embers extinguished.

6 = Flame @ 30 sec. and embers @ 60 sec., with embers extinguished.

7 = Flame @ 60 sec. with flames and embers extinguished.

The environmental conditions that afternoon were clear, 10ºC (50ºF), and an average relative humidity of 83%. It had been a week since any measurable amount of rain had fallen (Anonymous, 2002b).

Note: Data from the torch ignition tests were evaluated using analysis of variance with mean separations using the least significant differences. Ignition following the cigarette ignition and match ignition tests was rated in a binary fashion as either igniting or not and evaluated using logistic regression tests. Differences were determined using Fisher's Exact Test.

Results and Discussion

Cigarette Trials

Averaging the two cigarette trials, cigarettes discarded on the mulch surface ignited composted yard wastes and ground recycled pallets more often than ground rubber, pine straw, shredded hardwood, 1/2-inch pine bark nuggets, cocoa shells, and brick chip mulches and bluegrass sod (Table 1).

Oat straw, shredded cypress bark, 1/2- to 1-inch pine bark nuggets, and shredded pine bark ignited infrequently enough that they were not statistically different than those that never ignited (Table 1). Interestingly, oat straw only ignited during the first trial, while shredded cypress bark, recycled yard wastes, and shredded pine bark only ignited after being in the landscape for six months (data not shown).

Further, the type of cigarette affected the ignition. Three different types of cigarettes were used on each replication, and highly filtered cigarettes generally burned out before igniting the mulch. Unfiltered cigarettes were generally the cause of ignition when the mulch ignited.

Match Tests

Some mulches were also ignited by matches, but the match ignition test was not repeated. So few replicates of the various types of mulch ignited this way that statistical differences were not significant.

The match test was done after the mulches had been in place for six months. Although not statistically significant, some replicates of pine straw, oat straw, and the decorative ground rubber sometimes ignited using matches (data not shown).

Once ignited, the ground rubber was extremely difficult to extinguish.

Torch Tests

As expected, sod and brick chips did not ignite under any of the conditions tested. Additionally, the brick chips did not rapidly expand or explode, even with longer ex-

Table 1. The Number of Times That Specific Mulch Types Ignited After Three Cigarettes Were Discarded on the Surface of the Mulch. Each Trial Was Conducted Twice on Each of the Four Replicates.

Mulching Material	Times Ignition Occurred[z]
Ground recycled pallets	4[y]
Composted yard waste	4[y]
Shredded pine bark	3
Oat straw	2
Shredded cypress bark	2
Pine bark nuggets (1/2 to 1-inch)	1
Decorative ground rubber	0
Pine straw (needles)	0
Shredded hardwood bark	0
Pine bark nuggets (1 to 2-inch)	0
Cocoa shells	0
Bluegrass sod	0
Brick chips	0

[z] Ignition of each mulch was attempted eight times (2 trials x 4 replicates) using lighted cigarettes.
[y] Mulches that ignited four times (typically after aging or during the second test) out of eight attempts, were different, at the 0.05 level of significance, from mulches that never ignited using the Fisher's Exact Test. Logistic regression showed no differences between mulches that sometimes ignited.

posure to the flame of up to three minutes. Only debris such as grass clippings on the brick mulch burned, but it was not in sufficient quantity to allow the flame to propagate itself after the torch was removed. The torch killed grass foliage in the sod replication, but the live tissue did not allow the flame to propagate itself after the torch flame was removed.

One of the most ignition resistant of the organic mulches was cocoa shells. Cocoa shells were statistically more fire resistant (alpha = 0.05) than decorative ground rubber, pine needles, oat straw, shredded hardwood bark, and shredded cypress bark (Table 2).

Composted yard waste and dyed ground recycled pallets responded interestingly and resisted ignition using the propane torch for 15 seconds (Table 2). Cigarettes, on the other hand, ignited both materials as readily as any material (Table 1). Composted yard waste smoldered when ignited by cigarettes but did not burst into flame; however, the recycled pallets, when left smoldering for five minutes, did burst into flame.

The longer the time that a cigarette smolders on the surface may well be the difference. Smoldering mulch (duff) may be as dangerous as flaming mulch to the surrounding plants (Dickinson and Johnson, 2001) and introduces the impact of soil heating that is not seen when the duff layer does not smolder (Miyanishi, 2001). The smoldering mulch might well escape detection and be allowed to burn longer. Further, the longer the time that smoldering mulch would be in contact with the bark of a tree or a shrub might result in greater cambial heating and thus more extensive cambial injury.

Hardwood and pine bark mulch products were generally intermediate in tolerance to torch ignition. While not always statistically significant, pine bark mulch products were more torch resistant than hardwood products (Table 2). While hardwood mulches

Table 2. Ignition Ratings of 13 Mulching Materials Commonly Used in Landscape Maintenance Operations. Ease of Ignition Ratings Is the Average of the Torch Trials with Four Replicates in Each Trial.

Mulching Material	Ease of Ignition Rating[z]
Decorative ground rubber	7.00
Pine straw (needles)	6.88
Oat straw	5.00
Shredded hardwood bark	4.13
Shredded cypress bark	4.00
Ground recycled pallets	3.75
Pine bark nuggets (1 to 2-inch)	3.25
Pine bark nuggets (1/2 to 1-inch)	3.13
Shredded pine bark	2.88
Cocoa shells	2.63
Composted yard waste	2.13
Bluegrass sod	2.13
Brick chips	1.13
LSD_{05}	1.19

[z] **Ease of ignition ratings:**
1 = No flame @ 15 sec. No embers @15 sec.
2 = Flame @ 15 sec. No embers @ 30 sec.
3 = Flame @ 15 sec. Embers @ 30 sec. No embers @ 60 sec.
4 = Flame @ 30 sec. No embers @ 60 sec.
5 = Flame @ 15 sec. Embers @ 60 sec. Extinguished.
6 = Flame @ 30 sec. Embers @ 60 sec. Extinguished.
7 = Flame @ 60 sec. Extinguished.

caught fire, the flames and embers usually died out without being extinguished. Generally, the torch ignitions failed to propagate themselves with ease of ignition ratings below 4 with the exception of shredded hardwood bark.

Pine straw and oat straw usually had to be put out by the investigators as shown by their ease of ignition ratings of 5 or higher (Table 2). Simply speaking, the fires were propagating themselves during torch ignition. These mulches would be expected to be a significant concern in the landscape.

Decorative ground rubber ignited each time it was exposed to the propane torch and produced spreading flames in 60 seconds. Decorative ground rubber always had to be extinguished (Table 2). The flames often spread rapidly and deeply into the material. They were extinguished with difficulty by beating the flames out. Water would spread the burning material. Decorative ground rubber is sometimes recommended for use in playgrounds to cushion falls but, in our judgment, is far too easily ignited for this use. The article *Playground Fires Tied to Cigarettes* reaffirms our concern (*Columbus Dispatch,* 1997).

The mulches that were the most fire resistant under all methods of ignition were: cocoa shells, sod, 1- to 2-inch pine bark nuggets, shredded hardwood, and brick chips under the test parameters. These mulches might serve as standards for further testing.

One of the purposes of this study was to employ natural landscape conditions and to identify areas for further study. Some of the mulches were ignited by cigarettes that smoldered on the mulch surface for several minutes but not by 15 seconds of exposure to the torch, even though the torch ignition temperature was presumably much higher. This suggests that the length of time the mulch is subjected to the ignition source as well as its actual temperature will affect mulch ignition. Moisture content of the mulches is another area deserving of study. Finally, the ignition point of various mulches should be defined under standardized test conditions.

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IR-4 Ornamental Trials Conducted by USDA-ARS in Ohio: 2002

Betsy A. Anderson, Michael E. Reding, Michael G. Klein, and Charles R. Krause

Summary

A shortage of pest control products registered for use on ornamental crops is an ongoing problem. Interregional Research Project No. 4 (IR-4) is a government- and university-sponsored program developed to facilitate registration of new products and expand labels for effective products for minor crops. IR-4 receives funding from the United States Department of Agriculture (USDA), through the Cooperative State Research, Education, and Extension Service (CSREES) and the Agricultural Research Service (ARS).

Individual growers, grower organizations, university researchers, and Extension personnel initiate project requests. Each year a list of more than 4,000 researchable ornamental projects is compiled that includes trials of insecticides, fungicides, nematicides, bactericides, and herbicides. Data collected from the trials is sent to IR-4 Headquarters for review and coordination with the company making the product, and submission is made to the EPA for registration approval.

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Introduction

Each year the Application Technology Research Unit (ATRU), USDA/ARS, in Wooster, receives funding to conduct some 60 IR-4 trials on The Ohio State University's Ohio Agricultural Research and Development Center (OARDC) campus and in Ohio nurseries.

Selected greenhouse, field, and container-grown ornamental plant projects are conducted on OARDC's Wooster campus. OARDC provides field and greenhouse space and a hoop house in Secrest Arboretum where most of the container tests are performed. Most of the data needed for product registration is for phytotoxicity, but sometimes efficacy data is also required.

For the past two years, we have also conducted insecticide trials in Lake County, Ohio, to collect efficacy data on two non-native insect species that are located in isolated areas of northeastern Ohio.

Methods and Materials

Each test included untreated control plants and three pesticide treatment rates — 1X (the rate recommended by the manufacturer), 2X, and 4X. The tests had four, six, or 10 replications.

Field container test plants were transplanted into two-gallon containers using an amend-

ed pine bark medium and set up in an outdoor nursery in a randomized complete block design. Field test trees and shrubs were planted in rows separated by rows of grass in a completely randomized design. Greenhouse plants were planted in one-gallon containers and placed on benches in a greenhouse. Plants were rated for phytotoxicity four times during the growing season after the first treatment.

Efficacy data was requested for the insecticide trials — Thiamethoxam (Flagship) for control of white grubs, Japanese beetle larvae (*Popillia japonica*), and European chafer larvae (*Rhizotrogus majalis*), and trichlorfon (e.g., Dylox) for control of oriental beetle larvae (*Anomala orientalis*).

In an effort to get the needed data, the container tests were infested with eggs of European chafer and oriental beetle. Two field tests were conducted on rhododendrons in a nursery known to have problems with European chafer in field-grown nursery stock, and a third was conducted in a field of hemlocks that was naturally infested with third-instar larvae of European chafer.

Results

Phytotoxicity results are shown in Table 1. Most trials showed no phytotoxicity, although both formulations of the herbicide flumioxazin caused chlorosis and necrosis on the two plant species, *Deutzia gracilis* and *Phalaris arundinacea* (Ribbon-grass). The fungicide *Bacillus subtilis* caused necrotic leaf margins and spotting on *Verbena canadensis* and *Impatiens hawkeri*. Acibenzolar, a plant protectant, reduced flowering after the third and fourth treatments on *Impatiens balsamina*.

Efficacy data was not obtained in the insecticide container tests or the rhododendron field tests due to poor survival of grubs in control plants. The naturally infested field of hemlocks showed stunting from European chafer larval feeding and yielded efficacy data for the trichlorfon (e.g., Dylox) drench applications. The three Dylox treatment rates all had significantly fewer grub numbers than the untreated trees (the average number of grubs was 3.2 and 1.1 in the untreated controls and 1X rate of Dylox, respectively).

Note

Nursery growers should let their pest control needs be known by submitting a request electronically from the IR-4 website:

www.cook.rutgers.edu/~ir4

or by calling Betsy Anderson, USDA/ARS, at 330-263-3898 or by e-mailing

anderson. 523@osu.edu.

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Disclaimer

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Table 1. These 64 Tests Were Conducted by USDA-ARS in Wooster and Lake County, Ohio During 2002.

Pesticide	Crop	Site	Phytotoxicity
Insecticides			
Thiamethoxam (Flagship25WG)	Arborvitae	Field Container	0
To control white grubs,	Arborvitae	Field	0
Japanese beetle larvae, and	Butterfly Bush	Field	0
European chafer larvae.	Euonymus	Field Container	0
	Pine, Austrian	Field Container	0
	Pine, Mugo	Field	0
	Pine, Scotch	Field Container	0
	Pine, White	Field Container	0
	Rhododendron	Field	0
	Spruce, Colorado	Field Container	0
	Spruce, Serbian	Field Container	0
	Spruce, White	Field Container	0
Trichlorfon (Dylox80SP)	Andromeda	Field Container	0
To control oriental beetle	Azalea	Field Container	0
larvae.	Hemlock	Field	0
	Juniper	Field Container	0
	Rhododendron	Field Container	0
	Rhododendron	Field	0
Fungicides			
Acibenzolar (Actigard50WP)	Balsam	Greenhouse	*1x, 2x, 4x
For *Pseudomonas* and	Chrysanthemum	Greenhouse	0
Xanthomonas pathogens.	Geranium	Greenhouse	0
	Snapdragon	Greenhouse	0
Bacillus subtilis (Rhapsody AS)	Andromeda	Greenhouse	0
For powdery and downy	Balsam	Greenhouse	0
mildews, *Botrytis, Xanthomonas,*	Chrysanthemum	Greenhouse	0
and leafspots.	New Guinea Impatiens	Greenhouse	*2x, 4x
	Vervain	Greenhouse	*2x, 4x
Trifloxystrobin (Compass50W)	Balloon Flower	Field Container	0
For *Cladosporium, Botryosphaeria,*	Batchelor's Button	Field Container	0
Mycosphaerella, Alternaria, Septoria,	Beard-tongue	Field Container	0
Colletotrichum, Rhizoctonia, and	Beautyberry	Field Container	0
Sphaerotheca.	Bee Balm	Field Container	0
	Bellflower	Field Container	0

* = Phytotoxicity was noted on some or all of the plants with these treatment rates.

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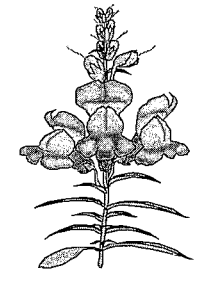
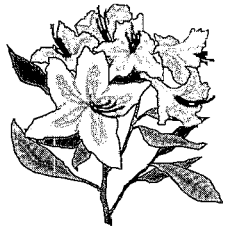


Table 1 (continued). These 64 Tests Were Conducted by USDA-ARS in Wooster and Lake County, Ohio, During 2002.

Pesticide	Crop	Site	Phytotoxicity
Trifloxystrobin (Compass50W) (continued)	Blazing Star	Field Container	0
	Heather	Field Container	0
	Hemlock	Field Container	0
	Hollyhock	Field Container	0
	Honeysuckle	Field Container	0
	Maidenhair Tree	Field Container	0
	Pincushion Flower	Field Container	0
	Speedwell, Brooklime	Field Container	0
	Spiderwort	Field Container	0
	Stokes Aster	Field Container	0
	Sweet Woodruff	Field Container	0
Herbicides			
Flumioxazin (Broadstar 0.17G) For weeds, broadleaf & annual grasses, and liverwort.	Boxwood	Field	0
	Bridal-wreath Spirea	Field	0
	Candytuft	Field Container	0
	Cherry	Field	0
	Douglas fir	Field Container	0
	Flowering Dogwood	Field Container	0
	Fountain Grass	Field	0
	Maple, Japanese	Field	0
	Mondo Grass	Field Container	0
	Potentilla	Field Container	0
	Ribbon-grass	Field Container	*1x, 2x, 4x
	Yew	Field Container	0
	Yew	Field	0
Flumioxazin (Valor WDG) For weeds, broadleaf & annual grasses, and liverwort.	Azalea	Field Container	0
	Butterflybush	Field	0
	Deutzia	Field Container	*1x, 2x, 4x
	Ribbon-grass	Field Container	*1x, 2x, 4x
	Rosemary	Field Container	0
	Smoketree	Field Container	0
	Vervain	Field Container	0

* Phytotoxicity was noted on some or all of the plants with these treatment rates.
- None of the test plants showed phytotoxicity.



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Research on Black Vine Weevil and White Grubs in Ornamental Nurseries in Ohio by USDA-ARS

Michael E. Reding, Michael G. Klein, Ross D. Brazee, and Charles R. Krause

Introduction

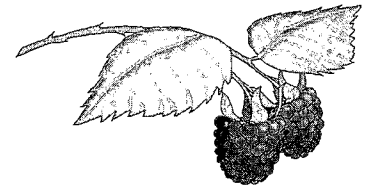
Some ongoing research projects, conducted by the Horticultural Insects Research Lab of the U.S. Department of Agriculture's Agricultural Research Service (ARS), Application Technology Research Unit, at the Ohio Agricultural Research and Development Center, Wooster, Ohio, are reported here. Most of this research focuses on the biology and management of black vine weevil *(Otiorhynchus sulcatus)* and various exotic scarab grubs (Asiatic garden beetle, *Maladera castanea;* European chafer, *Rhizotrogus majalis;* Japanese beetle, *Popillia japonica;* and oriental beetle, *Anomala orientalis)* in ornamental nurseries.

Black Vine Weevil Research

In 2002, the authors conducted several trials related to the management of black vine weevil (BVW). We tested traps to use for monitoring adults; we are evaluating various spray programs against adults in field-grown *Taxus* (yews); and we tested a number of insecticides and entomopathogenic nematodes as rescue treatments against larvae in containerized plants.

Michael E. Reding, Michael G. Klein, Ross D. Brazee, and Charles R. Krause, U.S. Department of Agriculture, Agricultural Research Service, Application Technology Research Unit, Wooster, Ohio.

Black vine weevil is a serious pest of field-grown *Taxus* and various ornamental species in containers. It is also a pest of many small fruits, including strawberry, raspberry, grape, and cranberry.



In general, damage to ornamental plants is caused by the larval stages, which feed on the roots and girdle stems. BVW has a one-year life cycle. Eggs are laid in the soil during mid- to late summer, and BVW spends the winter as larvae in the soil. Adult weevils emerge from the soil during late May through early July.

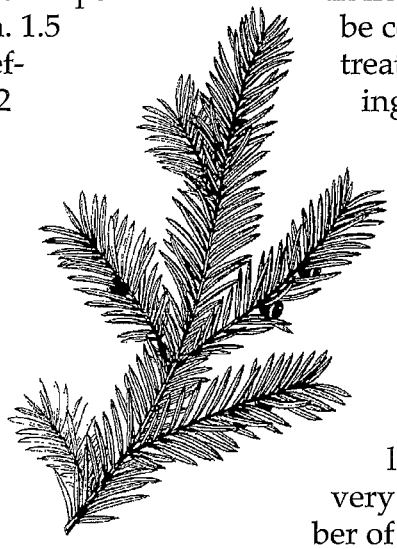
After emergence, adult BVW require about three to four weeks of feeding to mature their ovaries so they can lay eggs. All BVW are females, so mating does not occur.

In field-grown *Taxus,* current guidelines for management of BVW are based on insecticide treatments against adults. Sprays should begin when adults first emerge.

However, detecting the first emergence of adults is not easy. Adult BVW are active at night and seek out concealed sites in the canopy or debris on the ground during the day.

Currently, monitoring consists of either beating plants to dislodge adults onto the ground or by searching for fresh feeding injury (notching on the needles). An efficient reliable trap that would allow growers to detect adults when they begin emerging from the soil would make monitoring much easier and more effective.

In 2002, we tested three types of traps in a commercial *Taxus* field (ca. 1.5 acres). Two of the traps were effective. One was made from 12 in. x 12 in. x 1 in. boards with 1/4-inch grooves cut into one side. These traps were placed grooved side down beneath the canopy of plants, creating a "concealed" site for the adults during the day.



The other successful trap was a pitfall trap made from two 16-oz. plastic drinking cups. A hole was dug under the canopy of a plant, and the first cup was placed into the hole so that it was level with the soil surface. The second cup had a barrier of grease smeared around the inside rim and was placed inside the first cup. The weevils fell into the second cup and could not get out because of the grease. This cup could be removed to count the BVW. The third type of trap was a "deep-pan" trap made from a small dog-food dish. This trap was not very effective.

Twenty-one of each trap type were deployed in a grid pattern throughout the field. The board traps appeared to be the most effective, because they captured BVW on two dates before the pitfall traps made their first capture. Weekly plant-beat sampling was conducted in this field by Ohio State University graduate student Gina Penny, and board traps made captures before she detected adults by beating (11 and 13 June vs. 17 June, respectively).

This trial was conducted in a heavily infested field that was unsprayed (no insecticides) since 2000; therefore, testing in fields under normal management conditions is needed.

In another project, the authors are evaluating various spray programs against adults in field-grown *Taxus*. There appears to be confusion regarding the number of treatments necessary and when spraying can stop.

In 2002, the authors began a trial to determine the number of adult sprays necessary to achieve acceptable control of BVW. However, this trial will not be evaluated until April 2003. At that time, we will dig up the plants and count the number of BVW larvae present. Because there is very low tolerance for BVW, the number of larvae in successful treatments will have to be zero or almost zero.

In Spring 2002, we evaluated a number of insecticides and species of nematodes for efficacy as rescue treatments against BVW larvae in containerized plants (Astilbe, 1-gallon pots). Unfortunately, none of these treatments provided 100% control. The best control we achieved was 81% with an unregistered pyrethroid that was injected into the soil and 79% control with entomopathogenic nematodes (*Heterorhabditis bacteriophora* HP88) drenched onto the soil surface.

The nematodes and some of the insecticides might have worked better if we had given them more time. The trial was evaluated seven days after treatment, and 14 days might have been more appropriate. In re-

search trials, nematodes have often been effective against BVW larvae in containers. However, one constraint to using nematodes is soil temperature. Nematodes are generally most effective when soil temperatures are 60ºF or above. This trial was kept in the lab at room temperature (ca. 73ºF) after treatment.

Research on White Grubs

The authors are investigating various aspects of the biology and management of the exotic white grub complex in nurseries in northern Ohio. Our projects include studying the life history of oriental beetle (OB), natural enemies of OB and Japanese beetle (JB), and testing subsurface applications of insecticides as rescue treatments against white grubs in field-grown ornamentals.

There are several exotic scarab beetles (white grubs) that are pests in ornamental nurseries in northern Ohio. In the past, these beetles were considered primarily as contaminant pests in ornamentals, which was related to quarantine issues. However, during 2001 and 2002, we received more reports of damage to woody ornamentals caused by the root feeding of grubs.

In autumn 2001, European chafer (EC) grubs were killing PJM Rhododendrons in a commercial nursery in northern Ohio. Another incident of EC grubs killing plants occurred in a field of Canadian hemlocks *(Tsuga canadensis)* in a different northern Ohio nursery during autumn 2002. Both fields were about two acres and were infested with about three EC grubs per plant.

We conducted trials to test rescue treatments in both sites. In the rhododendrons, we tested subsurface applications of Dursban TNP. We had three applicators that allowed us to inject the insecticide into the soil. Two of the applicators had single-point nozzles that were inserted into the soil, and the insecticide was sprayed below the soil surface. The third applicator had a high pressure nozzle with a splash guard that injected insecticide into the soil from the surface using high pressure. Treatments with all three applicators were effective in the rhododendron field, reducing grub numbers by 95 to 100% compared with untreated plants.

In the hemlock trial (autumn 2002), a single-point subsurface treatment of Dursban TNP was compared with surface drenches of Dursban TNP and Dylox 80SP. The subsurface treatment of Dursban and the Dylox drench had significantly lower numbers of grubs than the untreated trees, reducing grub numbers by 95% and 69%, respectively. The Dursban drench treatment had grub numbers similar to the untreated trees. Dursban tends to get bound up with organic matter in the soil. Consequently, when used as a drench, Dursban does not penetrate the soil far enough to reach the grubs in the roots of trees and shrubs.

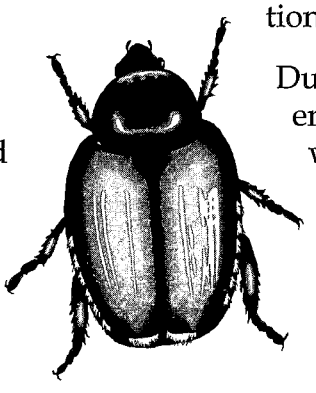
Knowledge of pest biology and ecology is necessary for the development of non-chemical management strategies. This information is also important for making chemical-based management as efficient and effective as possible.

In general, members of the exotic white grub complex have a one-year life cycle with the following life stages: egg, three larval (grub) stages (instars 1 to 3), prepupa (transition stage from third instar larva to pupa), pupa, and adult. These species overwinter primarily in the third larval stage with a small percentage of some species overwintering as second-stage larvae. Some individuals that overwinter as second-stage larvae take two years to complete development (two-year life cycle).

In 2001, we noticed a larger percentage of OB overwintering as second-stage larvae than expected. If a large number of OB overwinter as second-stage larvae, some management tactics might be less effective.

Imidacloprid (Merit, turf and landscape; Marathon, ornamental nursery) and halofenozide (Mach-2) are reduced-risk insecticides commonly used to control scarab grubs in turf and ornamentals. These materials are most effective when they are timed to target the eggs and first-stage larvae. In northern Ohio, this timing is generally late June through mid-July.

However, the two-year life-cycle individuals are second- or third-stage larvae at that time and would be less susceptible to treatments of insecticides, especially imidacloprid or halofenozide. If large numbers of OB have a two-year life cycle, treatments of imidacloprid or halofenozide may not prevent damage. In addition to their potential to cause damage, the surviving grubs may be contaminants, resulting in quarantine issues.



In 2002, the authors started a project that focused primarily on studying the life history of OB in nurseries of northern Ohio. In addition, we collected information on the occurrence and life histories of the other main members of the white grub complex, Asiatic garden beetle (AGB), EC, and JB. Previously, most of the information concerning the biology and management of white grubs came from research in turf.

We surveyed five nurseries, and OB, AGB, EC, and JB were found in four of them. In one nursery, only EC and JB were found. In general, the life histories of the four species were very similar, with EC developing about two weeks earlier than the rest. In addition, the time period of adult activity was much shorter for EC than the other species.

Life history of OB was studied extensively at two nurseries. At one nursery, the percentage of two-year life-cycle OB was within the range of previously reported levels (<15% of the population). At the second nursery, the percentage was very high (about 40%). These two nurseries were only about a mile apart. These data suggest that OB has a very flexible life history, which may allow it to adapt to a variety of climatic conditions.

During the 1920s and 30s, a natural enemy (*Tiphia vernalis*, a parasitic wasp) of JB was transported from China and Korea and released into the eastern United States. During the 1940s, there were a few releases made in Ohio from colonies that had established in the United States. In 2001, we found this parasite in a Lake County nursery. At that time, we discovered it attacking OB as well as JB.

In 2002, we surveyed several nurseries in Lake County to determine how common it was and which species of grubs it parasitized. We found *T. vernalis* in three nurseries. At one nursery, it was attacking JB and OB. At another nursery, it attacked only JB, but the OB population was low there. At the third nursery, we found adults but never found any parasitized grubs. This nursery had a lot of OB and very few JB.

We will be continuing all of the previously mentioned projects in 2003 and will add several others.

Acknowledgments

We thank Betsy Anderson, Jim Moyseenko, Susan Schlader, Will Driscol, and Tina Berry for their technical assistance and hard work on all our projects. We also thank Gina Penny, Dan Herms, and Randy Zondag for their assistance in finding potential research sites and for updates on pest development.

We also thank the following nurseries for their willingness to provide survey sites, research sites, plant material, and/or apply injection treatments: Arcola Creek Nursery; Brotzman's Nursery, Inc.; Klyn Nurseries, Inc.; Herman Losely & Son, Inc.; Moretti Nursery, Inc.; Ridge Manor Nurseries, Inc.; and Sunleaf Nursery, LLP.

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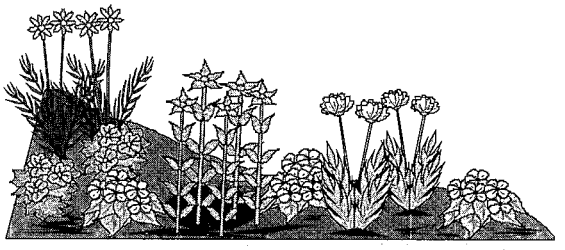
~ 15 ~
Herbaceous Ornamental Field Trial Results in Clark County, Ohio — 2002

Pamela J. Bennett



Introduction

Clark County Extension Master Gardener volunteers have planted, maintained, and evaluated annual plant varieties since 1995. Carolyn Allen and Barbara Brown are Master Gardener volunteer co-chairs of the project. The field trial plots are located at the Gateway Learning Gardens at the Clark County Extension Office in Springfield, Ohio. They are planted and maintained by volunteers.

The plots are typical of the west-central Ohio area. The soil is predominantly clay with a pH of 7.3. The current plots were established in the fall of 1996. The beds were tilled to a depth of 14" and 2" of compost was added. Compost is added when a new bed is established and again in three years. There is approximately 5,000 square feet of bed space in full sun and approximately 1,000 square feet in shade.

The selection of plants to be studied in the garden varies from year to year. The selection is based on performance in prior years, on current trends, and on industry recommendations. This section presents the performance results for the plants. The data reflect the growing conditions during 2002.

The purpose of the evaluation is to provide growers, landscapers, and homeowners a guide for plant selection for Ohio.

Method

The plants were started from seed, plugs, or cuttings at a local greenhouse, according to the recommended starting dates. They were planted in the plots on May 23, 2002. The rows were spaced 2 ft. apart with 6 plants of each variety in each row. Trailing or vining plants were spaced 4 ft. apart with 4 ft. between rows. Osmocote (14-14-14) was incorporated at the labeled rate prior to planting. Beds were hand weeded as needed throughout the season.

Irrigation was applied during dry periods so that plants received at least 1 inch of water per week. See the weather information for details. No additional applications of fertilizers were made. The plants were not deadheaded or pruned during the growing season. No insecticides or fungicides were applied. Volunteers weeded the plots as needed; no mulch was used. Plants were grown in full sun, unless otherwise indi-

Pamela J. Bennett, Ohio State University Extension, Horticulture, Clark County.

cated. The material for the shade house provided 75% shade.

Three people conducted visual evaluations in June, July, and August. These monthly evaluations were averaged for the overall rating for each variety. The monthly rating was based on the visual appearance of all plants. If there were less than three plants remaining at any time during the evaluation, the variety was dropped from the trials. A rating of 5 was considered to be excellent and a rating of 1 was considered to be poor. The overall rating is an average of the monthly totals.

Weather Information

Precipitation for May was above average while temperatures were slightly below normal. Despite wet soil conditions during most of May, the annuals were planted under excellent soil conditions. Temperatures were above normal in June, July, and August. August was warmer and drier than normal. Supplemental irrigation was applied in order to provide 1 inch of water per week. Weather conditions for this growing season as well as normal average temperatures and precipitation are shown in Table 1.

The varieties studied in the 2002 field trials and their monthly ratings and overall rating are indicated in Table 2. Ratings are in order of highest to lowest overall rating. Varieties that were grown under the shade structure were grown under a 75% shade cloth. The supplier for each annual is listed in the table.

Table 1. Weather Conditions for the 2002 Growing Season in Clark County, Ohio, as Well as Normal Average Temperatures and Precipitation.

2002	May	June	July	August	September
Temperature			ºF		
Average **high** temperature	69.7ºF	84.3ºF	87.4ºF	85.4ºF	82.3ºF
Average **low** temperature	47.3ºF	61.8ºF	64.3ºF	63.2ºF	55.0ºF
Average temperature	58.1ºF	72.6ºF	75.7ºF	73.3ºF	68.3ºF
Normal average temperature Fº	61.3ºF	70.3ºF	73.8vF	72.0ºF	65.2ºF
Precipitation					
Normal average rainfall (inches)	4.59″	4.16″	4.08″	3.5″	2.99″
2002 Rainfall (inches)	6.32″	5.06″	7.46″	1.7″	6.76″
Days over 90ºF	0	7	10	9	4

Table 2. Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Angelonia 'Angelmist Lavender Improved'	BFP	5.00	5.00	5.00	5.00
Coleus hybridus 'Inky Fingers'	MG	5.00	5.00	5.00	5.00
Coleus hybridus 'Flirtin Skirts'	MG	5.00	5.00	5.00	5.00
Coleus hybridus 'Inky Pink'	SG	5.00	5.00	5.00	5.00
Coleus hybridus 'Alabama Sunset'	MG	5.00	5.00	5.00	5.00
Petunia x *hybrida* 'Tidal Wave Silver'	BurSee	4.67	5.00	5.00	4.96
Nierembergia hippomanica 'Fairy Bells Compact White'	JP	4.67	5.00	5.00	4.96
Coleus hybridus 'Kingwood Kritter'	SG	4.67	5.00	5.00	4.96
Lantana camara 'Dallas Red'	MG	4.67	5.00	5.00	4.96
Lantana camara 'New Gold'	MG	4.67	5.00	5.00	4.96
Petunia x *hybrida* 'Lavender Storm'	GS	4.67	5.00	5.00	4.96
Petunia x *hybrida* 'Tidal Wave Cherry'	BallSd	4.33	5.00	5.00	4.93
Petunia x *hybrida* 'Tidal Wave Hot Pink'	BallSd	4.33	5.00	5.00	4.93
Coleus hybridus 'Painter's Palette'	SG	4.33	5.00	5.00	4.93
Salvia farinacea 'Victoria Blue'	BallSd	4.00	5.00	5.00	4.89
Petunia x *hybrida* 'Hurrah Coral Flare'	SSI	4.00	5.00	5.00	4.89
Petunia x *hybrida* 'Primetime Violet Star'	SSI	4.00	5.00	5.00	4.89
Lantana camara 'Alba'	MG	4.00	5.00	5.00	4.89
Verbena hybrida 'Aztec Red'	BFP	5.00	4.67	5.00	4.85
Salvia farinacea 'Victoria White'	BallSd	3.67	5.00	5.00	4.85
Capsicum 'Holiday Flame'	PAS	3.67	5.00	5.00	4.85
Capsicum 'Masquerade'	PAS	3.67	5.00	5.00	4.85
Capsicum 'Explosive Ember'	SSI	3.67	5.00	5.00	4.85

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Lantana camara 'Patriot Sunburst'	MG	5.00	5.00	4.67	4.85
Salvia 'Victoria White'	BallSd	3.67	5.00	5.00	4.85
Angelonia 'Angelmist Purple Stripe'	BFP	3.33	5.00	5.00	4.81
Angelonia 'Angelmist White Improved'	BFP	3.33	5.00	5.00	4.81
Nierembergia hippomanica 'Fairy Bells Compact Blue'	JP	4.67	4.67	5.00	4.81
Begonia 'Dragon Wings Red'	PAS	3.33	5.00	5.00	4.81
Lantana camara 'Patriot Desert Sunset'	MG	4.67	5.00	4.67	4.81
Lantana camara 'Patriot Firewagon'	MG	4.67	5.00	4.67	4.81
Lantana camara 'Samantha'	MG	4.67	4.67	5.00	4.81
Petunia x *hybrida* 'White Storm'	GS	4.33	4.67	5.00	4.78
Capsicum 'Medusa'	PAS	3.00	5.00	5.00	4.78
Petunia x *hybrida* 'Pink Morn Storm'	GS	4.00	4.67	5.00	4.74
Petunia x *hybrida* 'Hurrah Parfait Mix'	SSI	4.00	4.67	5.00	4.74
Petunia x *hybrida* 'Hurrah Salmon'	SSI	4.00	4.67	5.00	4.74
Petunia x *hybrida* 'Bravo Cool Water Mix'	SSI	4.00	4.67	5.00	4.74
Coleus hybridus 'Solar Sunrise'	MG	4.00	4.67	5.00	4.74
Catharanthus roseus 'Big Ruby'	PAS	2.67	5.00	5.00	4.74
Catharanthus roseus 'Blue Pearl'	PAS	2.67	5.00	5.00	4.74
Catharanthus roseus 'Pacifica Icy Pink'	PAS	2.67	5.00	5.00	4.74
Coleus hybridus 'Green Earrings'	BallSd	5.00	4.33	5.00	4.70
Zinnia hybrida 'Profusion Orange'	BurSee	3.67	4.67	5.00	4.70

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Hypoestes phyllostachya 'Confetti Carmine Rose'	D	3.67	4.67	5.00	4.70
Coleus hybridus 'Kiwi Fern'	MG	3.67	4.67	5.00	4.70
Capsicum 'Chilly Chili'	PAS	3.67	4.67	5.00	4.70
Capsicum 'Red Missile'	PAS	3.67	4.67	5.00	4.70
Capsicum 'Explosive Ignite'	SSI	3.67	4.67	5.00	4.70
Cleome spinosa 'Sparkler Mix'	GS	4.67	5.00	4.33	4.67
Lantana camara 'Patriot Passion'	MG	4.67	5.00	4.33	4.67
Hypoestes phyllostachya 'Confetti White'	D	3.33	4.67	5.00	4.67
Coleus hybridus 'Pistachio Nightmare'	MG	4.67	4.33	5.00	4.67
Petunia x *hybrida* 'Avalanche Lilac'	BSL	4.33	4.67	4.67	4.63
Petunia x *hybrida* 'Avalanche White'	BSL	4.33	4.67	4.67	4.63
Ageratum houstonianum 'Leilani Blue'	GS	4.33	4.33	5.00	4.63
Spilanthes oleracea 'Peek-A-Boo'	PAS	4.33	5.00	4.33	4.63
Petunia x *hybrida* 'Bravo White'	SSI	4.33	4.33	5.00	4.63
Lantana camara 'Patriot Cherry'	MG	4.33	4.67	4.67	4.63
Lantana camara 'Patriot Petticoat'	MG	4.33	4.67	4.67	4.63
Begonia 'Dragon Wings Pink'	PAS	2.67	4.67	5.00	4.59
Catharanthus roseus 'Pacifica Burgundy'	PAS	2.33	4.67	5.00	4.56
Petunia x *hybrida* 'Bravo Blue Veined'	SSI	2.33	4.67	5.00	4.56
Coleus hybridus 'Dark Heart'	DSC	3.67	4.33	5.00	4.56
Hypoestes phyllostachya 'Confetti Red'	D	3.67	4.67	4.67	4.56
Hypoestes phyllostachya 'Confetti Wine Red'	D	3.67	4.67	4.67	4.56

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Begonia x *semperflorens* 'Queen Pink'	D	3.33	4.33	5.00	4.52
Verbena hybrida 'Temari Rose'	JP	4.67	4.67	4.33	4.52
Salvia splendens 'Vista Purple'	PAS	3.33	4.67	4.67	4.52
Capsicum 'Explosive Blast'	SSI	3.33	4.67	4.67	4.52
Verbena rigida 'Santos'	K	3.00	5.00	4.33	4.48
Cleome spinosa 'Queen White'	BallSd	4.33	5.00	4.00	4.48
Petunia x *hybrida* 'Ramblin' Peach Glo'	GS	4.00	4.67	4.33	4.44
Petunia x *hybrida* 'Ramblin' Burgundy Chrome'	GS	4.00	4.67	4.33	4.44
Petunia x *hybrida* 'Kahuna Violet'	SSI	4.00	4.67	4.33	4.44
Zinnia haageana 'Persian Carpet Mix'	TM	4.00	4.67	4.33	4.44
Cleome spinosa 'Queen Violet'	BallSd	4.00	5.00	4.00	4.44
Verbena hybrida 'AztecDark Purple'	BFP	5.00	4.67	4.00	4.41
Coleus hybridus 'Saturn'	MG	2.33	4.33	5.00	4.41
Hypoestes phyllostachya 'Confetti Pink'	D	3.67	4.67	4.33	4.41
Petunia x *hybrida* 'Madness Waterfall Mix'	BallSd	3.33	4.33	4.67	4.37
Calibrachoa 'Celebration Apricot'	DSC	4.67	5.00	3.67	4.37
Torenia 'Summer Wave Amethyst'	JP	4.67	4.67	4.00	4.37
Torenia 'Summer Wave Blue'	JP	4.67	4.67	4.00	4.37
Petunia x *hybrida* 'Bravo Pink Flare'	SSI	3.33	4.33	4.67	4.37
Cleome spinosa 'Queen Rose'	BallSd	4.33	4.67	4.00	4.33
Catharanthus roseus 'Heatwave Blue with Eye'	BSL	1.67	4.67	4.67	4.33

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Begonia x *semperflorens* 'Varsity Pink Improved'	SSI	3.00	4.33	4.67	4.33
Cleome spinosa 'Queen Cherry'	BallSd	4.00	4.67	4.00	4.30
Catharanthus roseus 'Pacifica Mix'	PAS	2.67	4.33	4.67	4.30
Catharanthus roseus 'Pacifica Polka Dot'	PAS	1.33	4.67	4.67	4.30
Zinnia elegans 'Cupidon Elite Mix'	BSL	3.67	4.33	4.33	4.26
Petunia x *hybrida* 'Blue Storm'	GS	3.67	4.67	4.00	4.26
Solanum jasminoides 'Aurea'	DSC	3.33	4.00	4.67	4.22
Petunia x *hybrida* 'Hurrah Pink Chiffon'	SSI	3.33	4.00	4.67	4.22
Lantana camara 'Patriot Rainbow'	MG	3.33	4.67	4.00	4.22
Petunia x *hybrida* 'Ultra Salmon'	GS	2.67	4.33	4.33	4.15
Catharanthus roseus 'Sunstorm Orchid'	SSI	2.67	4.33	4.33	4.15
Catharanthus roseus 'Sunstorm Apricot'	SSI	1.33	4.33	4.67	4.15
Salvia argentea	*DSC*	*3.67*	*4.67*	*3.67*	*4.11*
Zinnia hybrida 'Profusion Cherry'	FGC.	3.67	4.00	4.33	4.11
Salvia splendens 'Salsa Scarlet'	GS	3.67	4.00	4.33	4.11
Coleus hybridus 'Black Dragon'	PAS	2.33	4.00	4.67	4.11
Petunia x *hybrida* 'Kahuna White'	SSI	3.67	4.33	4.00	4.11
Dahlia 'Dahlietta Patricia'	BFP	4.67	3.67	4.33	4.07
Petunia x *hybrida* 'Double Madness Pink'	BallSd	3.33	4.00	4.33	4.07
Celosia cristata 'New Look'	BS	2.00	4.33	4.33	4.07
Nemesia fructicans 'Sachet Parfait'	DSC	4.33	4.00	4.00	4.04
Begonia x *semperflorens* 'Ambassador Soft Pink'	DSC	3.00	4.33	4.00	4.04

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Zinnia angustifolia 'Star White'	FGC.	2.67	4.67	3.67	4.00
Zinnia elegans 'Dreamland Rose'	FGC.	4.00	4.33	3.67	4.00
Petunia x *hybrida* 'Surfinia Giant Purple'	JP	4.00	4.00	4.00	4.00
Catharanthus roseus 'Sunstorm Lilac'	SSI	2.67	4.00	4.33	4.00
Catharanthus roseum 'Sunstorm White/Eye'	SSI	2.33	4.33	4.00	3.96
Zinnia angustifolia 'Crystal White'	FGC.	3.67	4.67	3.33	3.96
Heliotropium arborescens 'Marine'	BallSd	4.67	4.00	3.67	3.93
Petunia x *hybrida* 'Madness Magenta'	BallSd	3.33	4.00	4.00	3.93
Zinnia 'Bright Jewels Mix'	BSL	3.33	3.67	4.33	3.93
Abutilon 'Souvenir De Bonn'	DSC	3.33	4.00	4.00	3.93
Lantana camara 'Patriot Cowboy'	MG	3.33	4.00	4.00	3.93
Impatiens hawkerii 'Superbowl Salmon'	DSC	4.33	3.33	4.33	3.89
Zinnia elegans 'Dreamland Scarlet'	FGC.	3.00	4.33	3.67	3.89
Petunia x *hybrida* 'Ultra White'	GS	2.67	3.67	4.33	3.85
Petunia x *hybrida* 'Surfinia Lime'	JP	4.00	4.33	3.33	3.85
Petunia x *hybrida* 'Wave Pink Improved'	PAS	4.00	4.33	3.33	3.85
Begonia x *semperflorens* 'Varsity Scarlet'	SSI	2.67	3.67	4.33	3.85
Verbena hybrida 'Aztec Plum'	SSI	5.00	3.67	3.67	3.81
Catharanthus roseus 'Sunstorm Formula Mix'	SSI	2.33	4.00	4.00	3.81
Verbena hybrida 'Tapiens Salmon'	JP	3.67	3.67	4.00	3.81
Coleus hybridus 'Super Duckfoot'	MG	3.67	3.00	4.67	3.81

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Petunia x *hybrida* 'Fantasy Mix'	GS	3.33	4.00	3.67	3.78
Zinnia hybrida 'Profusion White'	S	3.00	3.67	4.00	3.74
Petunia x *hybrida* 'Easy Wave Pink'	PAS	4.00	4.00	3.33	3.70
Salvia splendens 'Blue Ribbon'	PAS	4.00	4.00	3.33	3.70
Petunia x *hybrida* 'Celebrity Blue Crystal'	BSL	2.67	3.67	4.00	3.70
Zinnia elegans 'Candy Cane'	BSL	3.67	3.67	3.67	3.67
Lobelia 'Big Blue'	DSC	5.00	3.67	3.33	3.67
Begonia x *semperflorens* 'Victory Bronze Leaf White'	GS	2.33	3.33	4.33	3.67
Penta lanceolata 'Galaxy Venus'	DSC	2.00	3.33	4.33	3.63
Melampodium paludosum 'Showstar'	BallSd	2.00	4.00	3.67	3.63
Melampodium paludosum 'Melanie'	K	2.00	4.00	3.67	3.63
Verbena hybrida 'Calypso Mix Watercolor'	PAS	3.33	3.67	3.67	3.63
Rudbeckia hirta 'Autumn Colors'	BS	3.00	4.67	2.67	3.59
Rudbeckia hirta 'Prairie Sun'	BS	3.00	4.67	2.67	3.59
Petunia x *hybrida* 'Celebrity Plum Ice'	BSL	2.67	3.67	3.67	3.56
Bacopa 'Penny Candy Violet'	DSC	4.00	3.67	3.33	3.56
Lobelia erinus 'Blue Moon'	SSI	5.00	3.33	3.33	3.52
Salvia splendens 'Salvador Red'	SSI	3.33	3.33	3.67	3.48
Zinnia elegans 'Dreamland Ivory'	FGC.	4.00	3.67	3.00	3.41
Salvia splendens 'Salsa Purple'	GS	3.67	3.33	3.33	3.37
Zinnia elegans 'Small World Pink'	BSL	3.33	2.67	4.00	3.33
Zinnia elegans 'Dreamland Coral'	FGC.	3.33	3.67	3.00	3.33

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Portulaca grandiflora 'Margarita Apricot'	PAS	2.00	3.67	3.33	3.33
Portulaca grandiflora 'Margarita Lemon'	PAS	2.00	3.67	3.33	3.33
Penta lanceolata 'Galaxy Mars'	DSC	1.67	3.33	3.67	3.30
Petunia x *hybrida* 'Ramblin' Neon Rose'	GS	3.00	3.33	3.33	3.30
Verbena hybrida 'Temari Bright Coral'	JP	3.00	3.33	3.33	3.30
Monopsis unidentata 'Blue Papillo'	BFP	2.67	3.00	3.67	3.26
Salvia splendens 'Vista Red / White'	PAS	2.67	3.33	3.33	3.26
Hedera 'Mein Hertz'	DSC	2.33	3.00	3.67	3.22
Lobelia erinus 'Palace Sky Blue'	BSL	5.00	3.33	2.67	3.22
Lobelia erinus 'Royal Palace Improved'	BSL	5.00	3.67	2.33	3.22
Lobelia erinus 'Palace Blue'	BSL	5.00	2.67	3.33	3.22
Portulaca grandiflora 'Margarita Pastel Mix'	PAS	2.00	3.67	3.00	3.19
Catharanthus roseus 'Sunstorm Rose'	SSI	2.00	3.00	3.67	3.19
Salvia patens 'Blue Angel'	BS	3.00	3.33	3.00	3.15
Begonia x *semperflorens* 'Ambassador Mix'	D	3.00	3.00	3.33	3.15
Zinnia elegans 'Dreamland Pink'	FGC.	4.33	3.67	2.33	3.15
Petunia x *hybrida* 'Wave Blue'	PAS	3.00	3.33	3.00	3.15
Petunia x *hybrida* 'Ultra Red'	GS	2.67	3.33	3.00	3.11
Celosia spicatata 'Punky Red'	K	1.33	3.33	3.33	3.11
Lobelia erinus 'Palace White'	BSL	5.00	3.00	2.67	3.07
Dianthus barbatus 'Amazon Neon'	PAS	3.33	3.00	3.00	3.04

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Petunia x *hybrida* 'Bravo Red'	SSI	3.33	3.00	3.00	3.04
Nemesia fructicans 'Sachet Blueberry'	DSC	2.67	2.67	3.33	2.96
Helichrysum petiolatum 'Moe's Gold'	DSC	2.33	3.00	3.00	2.93
Zinnia elegans 'Dreamland Yellow'	FGC.	3.67	3.67	2.00	2.93
Lobelia erinus 'Palace Lilac'	BSL	4.67	2.67	2.67	2.89
Petunia x *hybrida* 'Easy Wave Cherry'	PAS	3.00	3.00	2.67	2.85
Begonia x *semperflorens* 'Ambassador Rose'	D	3.00	2.67	3.00	2.85
Cosmos sulphureus 'Sonata Series'	PAS	3.00	3.33	2.33	2.85
Argranthemum 'Comet White'	DSC	3.67	3.33	2.00	2.78
Gazania rigens 'Gazoo Yellow with Ring'	SSI	3.00	2.33	3.00	2.70
Argyranthemum 'Comet Pink'	DSC	3.00	3.33	2.00	2.70
Dianthus chinensis 'Floral Lace Cherry'	BallSd	3.67	2.33	2.67	2.63
Catharanthus roseus 'Sunstorm Bright Red'	SSI	1.00	3.33	2.33	2.63
Gazania splendens 'White Kiss'	GS	3.33	2.33	2.67	2.59
Hedera 'White Mein Hertz'	DSC	2.00	2.67	2.67	2.59
Tibouchina urvilleana	DSC	2.00	3.00	2.33	2.59
Petunia x *hybrida* 'Bravo Salmon Improved'	SSI	1.67	2.67	2.67	2.56
Rudbeckia hirta 'Toto Gold'	BS	3.00	3.33	1.67	2.56
Celosia cristata 'Flamingo Feather'	TM	1.67	3.00	2.33	2.56
Petunia x *hybrida* 'Ramblin' Nu Blue'	GSeds	2.67	2.67	2.33	2.52
Trachelium caerulelum 'Devotion Purple'	PAS	2.67	2.67	2.33	2.52

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Alonsoa meriodinales 'Rebel'	K	2.33	2.67	2.33	2.48
Petunia x *hybrida* 'Surfinia Pink Veined'	JP	2.00	3.33	1.67	2.44
Alternanthera dentata 'Purple Knight'	PAS	2.00	2.33	2.67	2.44
Impatiens wallerana 'Summer Ice Snow n' Ice'	DSC	3.00	2.33	2.33	2.41
Cosmos sulphureus 'Cosmic Orange'	BS	4.33	2.33	2.00	2.41
Verbena hybrida 'Quartz BurgundyEye'	PAS	3.00	2.67	2.00	2.41
Lavender Madrid Purple	BSL	2.67	2.33	2.33	2.37
Alyssum montanum 'Mountain of Gold'	BS	2.33	2.67	2.00	2.33
Zinnia elegans 'Zinnita Orange'	BS	3.33	2.33	2.00	2.30
Euryops Sonnenschein	DSC	2.67	2.00	2.33	2.25
Lavender 'Madrid Pink'	BSL	2.33	2.00	2.33	2.19
Dianthus chinensis 'Corona Cherry Magic'	PAS	2.33	3.00	1.33	2.19
Lavender Madrid White	BSL	2.00	2.00	2.33	2.15
Rudbeckia hirta 'Toto Rustic'	BS	3.00	3.00	1.00	2.11
Rudbeckis hirta 'Toto Lemon'	BS	3.00	3.00	1.00	2.11
Zinnia elegans 'Zinnita Yellow'	BS	3.00	2.00	2.00	2.11
Cosmos sulphureus 'Cosmic Yellow'	BS	4.00	2.00	1.67	2.07
Rudbeckia hirta 'Cordoba'	BS	2.67	3.00	1.00	2.07
Dianthus barbatus 'Noverna Purple'	K	2.67	2.00	2.00	2.07
Begonia Rex 'Caribbean Dreams'	DSC	2.00	1.67	2.33	2.00
Gazania splendens 'Daybreak Orange Cream'	PAS	3.33	1.67	2.00	2.00
Gazania Tiger Mix	BallSd	4.00	1.67	1.67	1.93

Table 2 (continued). Monthly Ratings and Overall Ratings for the 2002 Field Trials in Clark County, Ohio. Ratings Are in Order of Highest to Lowest Overall Rating.

Plant	Supplier*	June	July	Aug	Overall Rating
Bacopa 'Blue Showers'	DSC	2.67	1.67	2.00	1.93
Bacopa 'Candy Floss Blue'	DSC	2.67	1.67	2.00	1.93
Vinca minor 'Wojo's Gem'	WG	1.33	2.33	1.67	1.93
Impatiens hawkerii 'Superbowl Vivid Purple'	DSC	3.00	1.33	2.00	1.81
Verbena hybrida 'Temari White'	JP	3.00	1.67	1.67	1.81
Dianthus 'Ideal Formula Mix'	PAS	3.00	1.67	1.67	1.81
Dianthus chinensis 'Floral Lace Purple'	BallSd	4.00	1.67	1.33	1.78
Isotoma 'Blue and White Star'	K	3.33	1.33	1.67	1.70
Celosia cristata 'Amigo Mahogany Red'	BS	1.67	1.33	2.00	1.67
Gazania 'Kontiki Mix'	K	4.00	1.33	1.33	1.63
Dianthus chinensis 'Strawberry Super Parfait'	GS	2.67	1.67	1.33	1.63
Dianthus chinensis 'Magic Charms Mix'	GS	3.00	1.33	1.33	1.52
Dianthus chinensis 'Raspberry Parfait'	GS	2.67	1.33	1.33	1.48
Zinnia elegans 'Zinnita White'	BS	2.33	1.33	1.33	1.44
Verbena hybrida 'Temari Red / White Eye'	JP	1.33	1.33	1.33	1.33
Anigozanthus 'Joey Paws Lipstick'	BSL	1.33	1.00	1.00	1.04
Vinca minor 'Illumination'	DSC	1.33	1.00	1.00	1.04
Anigozanthus 'Joey Paws Red'	BSL	1.00	1.00	1.00	1.00
Anigozanthus 'Joey Paws Yellow'	BSL	1.00	1.00	1.00	1.00

Suppliers:

BFP – Ball FloraPlant
BallSd – Ball Seed Company
BS - Benary Seeds
BSL - Bodger Seeds, Ltd.
BurSee – Burpee Seeds
DSC - D.S. Cole Growers
D – Daehnfeldt
FGC – Fred C. Gloeckner & Co., Inc
GS – Goldsmith Seeds
JP – Jackson & Perkins Wholesale
K – Kieft
MG – Meadowview Growers
PAS – Pan American Seed Company
S – Sakata
SG – Skagit Gardens
SSI – Syngenta Seeds Inc.
TM – Thompson & Morgan
WG - Wojo's Greenhouse

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Results of Annual Trial Gardens at the Cincinnati Zoo and Botanical Garden for 2002

Dave Dyke

Ohio State University Extension's Hamilton County Horticulture Program, the Cincinnati Zoo and Botanical Garden (CZABG), the Cincinnati Flower Growers Association (CFGA), and the Ohio State University Master Gardener Program in Hamilton County collaborated to establish demonstration/trial gardens at the CZABG in the spring of 2002.

The gardens were designed by Steve Foltz, Horticultural Director, CZABG, and Dave Roberts, Horticulturist, CZABG. They were sponsored by PanAmerican Seed (Platinum Sponsor); Eason Horticultural Resources, Proven Winners, Syngenta, Fisher, and Paul Ecke (Gold Sponsors); and The Scott's Company, BFG Supply, Goldsmith Seed, Oglevee, and Grimes Seed Company (Silver Sponsors). CFGA members donated more than 4,000 plants to the project, including plugs of Tidal Wave Silver petunias and other varieties supplied by PanAmerican Seed and grown by Association members.

Two goals were set. The first was to provide the general public and commercial growers/landscapers an opportunity to observe many varieties of the latest available, yet fairly well-proven, annuals that were professionally grown in attractive garden settings (including in planters). The second was to evaluate those annuals on the basis of quality and performance as seen in the late summer. All of the 140 varieties in the trials were labeled for easy identification by the 1.1 million visitors to the Zoo in 2002. A major planting of Tidal Wave Silver petunias was made near a new entrance to the Zoo.

The gardens were irrigated but were still subjected to more than 25 days of temperatures in the 90s. Evaluations on the basis of quality and performance of the annuals were made over a two-week period from mid-August to late August of 2002. Those participating in the evaluations were members of the Cincinnati Flower Growers Association, Ohio State University Extension, Greater Cincinnati Master Gardeners Association, and the staff and volunteers of the Cincinnati Zoo and Botanical Garden.

A list of the best in the Zoo's Gardens in 2002 is presented here. Plants with a * are considered the 2002 Best-of-the-Best Zoo Annuals Picks. New trial gardens of both annuals and grasses are planned for 2003.

For more information, contact the Cincinnati Zoo and Botanical Garden Horticulture Department at 513-475-6106 or Dave Dyke of Ohio State University Extension at 513-505-1202.

Dave Dyke, Commercial Floriculture Agent, Ohio State University Extension, Hamilton County.

Table 1. 2002 Best-of-the-Best Cincinnati Zoo and Botanical Garden Annuals Picks.

Plant Name	Size	Flower Color	Foliage Color
Caladiums			
Caladium 'Candidum'	18"	NA	green & white
Caladium 'Carolyn Wharton'		NA	green/pink/rose
Caladium Red	1'-2'	NA	red center/green perimeter
Caladium 'Red Frill'		NA	red with green edges
Caladium 'White Christmas'	12"-18"	NA	green & white
Cannas			
* *Canna* 'Australia'	4'	red	burgundy
Canna 'Rosemond Cole'	4'	orange & yellow	green
Canna 'Dark Knight'	5'	scarlet	green w/ red veins
Canna 'Red Stripe'	7'		burgundy/green
Canna 'Liberty Yellow'	4'-5'	yellow	green
Canna 'Bengal Tiger'	5'-6'	orange	green
Canna 'Tropicana' Canna	5'	orange	red/green stripes
Coleus			
Coleus 'Alabama Sunset'	18"	NA	rose/green
Coleus 'Inky Pink'	18"	NA	pink / greenish tan
Coleus 'Kingwood Flame'	2.5'	NA	rose/deep rose
* *Coleus* 'Kingwood Torch'	2'-2.5'	NA	burgundy
Upright clump form annuals:			
Abutilon x *hybridum* 'Bella Pink' (flowering maple)	12"	pink	
Ocimum basilicum 'African Blue' (basil)	18"	blue	
Pachystachys lutea (shrimp plant)	16"	yellow	green
Pentas bussei 'Red' (Egyptian star flower)		red	
Plectranthus argenteus (spurflower)			silver-green
Rudbeckia hirta 'Indian Summer' (black-eyed Susan)		yellow/black center	
Salvia farinaceae 'Victoria' (sage)	14"	blue	silver-green
Salvia guaranitica	18"	blue	green
Salvia leucantha (Mexican sage)	3'	purple/white	silver-green
Erect form annuals:			
Asclepias curassavica 'Silky Red' (butterfly weed)	2.5'	orange red	green
Cuphea ignea 'Dynamite' (cigar flower)	3'		
* *Pennisetum setaceum* 'Rubrum' (fountain grass)	3'	purple	
Salvia coccinea 'Lady in Red'	2'	red	

Table 1 (continued). 2002 Best-of-the-Best Cincinnati Zoo and Botanical Garden Annuals Picks.

Plant Name	Size	Flower Color	Foliage Color
Mounding form annuals:			
Begonia hybrida 'Dragon Wing™ Pink'	2'	pink - dark pink	
Begonia hybrida 'Dragon Wing™ Red'	2.5'	red	green
* *Impatiens* x *hawkerii* 'Super Bowl (New Guinea impatiens)	16"	orange	dark green
* *Lantana camara* 'Ingelsheim'		orange/yellow/pink	green
* *Strobilanthes dyerianus* (Persian shield)	24"-30"		purple, lavender, green
Groundcover form annuals:			
Catharanthus roseus 'Pink Cooler' (periwinkle)	12"	pink/rose center	green
* *Lantana camara* 'New Gold'	4"	yellow	green
Lantana camara 'Samantha'	12"	yellow	variegated green and yellow
Lantana 'Dove Wings'	5"	white	green
Petunia 'Blue Wave™ '	6"		
Petunia 'Pink Wave™ Improved'	10"-12"	pink	green
* *Petunia* 'Tidal Wave™ Silver'	10"	silver/lavender	green
Petunia 'Purple Wave™ '	8"	purple	green
Verbena canadensis 'Homestead Purple'	4"	purple	green
Zinnia angustifolia 'Crystal White'	12"	white/orange center	green
* *Zinnia angustifolia* 'Star Gold'	6"	gold	green
Zinnia angustifolia 'Star White'		white/orange center	green
Zinnia x *hybrida* 'Profusion Cherry'	9"	raspberry green	
Zinnia x *hybrida* 'Profusion Orange'	10"	orange	green
Zinnia x *hybrida* 'Profusion White'	12"	white/yellow center	green
* *Torenia hybrida* 'Summer Wave Blue'	6"	purple	green
Trailing ground cover annuals:			
Ipomoea batatus 'Black Ace' (sweet potato vine)	5"	dark chocolate	
Ipomoea batatus 'Blackie'	5"	purple/green	
* *Ipomoea batatus* 'Marguerite'	10"	lime	

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Ohio State University Learning Garden Annual Cultivar Trials

Monica M. Kmetz-González and Claudio C. Pasian

Introduction

Annual Cultivar Trials began at The Ohio State University's Columbus campus in 2000, with the construction of eight raised beds and trellises by the Chadwick Arboretum staff. This Learning Garden area is located just south and west of our departmental buildings on the Columbus campus and also includes two cement raised beds and ground bed space.

The area is designated as the Murphy Family Garden, in memory of the family of Marilyn Murphy, a former longtime staff member of the department. This summer, a new ground bed area was added at the north side of the departmental buildings. It currently holds the 2002-03 Pansy and Viola Cultivar Trial. A further planned addition for the summer of 2003 is a container trial area, designated just south and west of the raised beds.

Previous Trials

Results from previous trials, as well as individual cultivar photos, can be accessed on the Worldwide Web at: **http://floriculture.osu.edu/trials/PageCrop1.html**

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Here is a sampling of what is available there:

- Summer Annuals 2001 Cultivar Trial Results of Lantana and Fuchsia, Heat-Tolerant Annuals, Heirloom Annuals, and Annual Vines.
- Osteospermum (Cape Daisy) 2001 Garden Trial
- Pansy and Viola 2000-01 and 2001-02 Cultivar Trial Results for both fall and spring performance evaluations.

Current Trials

Fall Pansy and Viola Cultivar Trial 2002-03

This trial is underway with 83 cultivars being screened for aesthetics, vigor, and overwintering. Plants were outplanted on September 11, 2002. The fall evaluation has taken place. Plants will now be observed over the winter and then evaluated again in the spring. They will remain in-ground until mid-May 2003.

Summer Annuals 2002

These trials were divided into three main areas — Cuphea Species, Under-Utilized Bedding Plants for the Ohio Landscape, and Annual Vines.

Preliminary results of the Cuphea Species Trial are presented here in Table 1.

Results

Summer Annuals 2002 — Cuphea Species Trial

A limited number of Cuphea types are available in the industry. This species trial was undertaken to identify new plants with potential ornamental value directly for landscape use or for incorporation into breeding programs.

Sources and the number of accessions in the trial are listed. Accessions were obtained in the form of vegetative cuttings, seed, or transplants, depending upon the source. Plants were grown in the departmental greenhouses until ready for transplant outdoors.

Plants were transplanted to raised beds in the trial area on May 16, 2002. Three plants per accession were placed on 3-foot centers. Plants received watering as needed using an overhead irrigation system. Fertilization took place on June 11 with 20-10-20 @ 200 ppm N, and on July 9 with 20-10-20 @ 125 ppm N.

As a note, temperatures in May after planting were unseasonably cold, followed by above average rainfall in June. July and August were excessively hot (day and night temperatures) and dry.

Evaluations were performed monthly by the Annual Trial Gardens Coordinator. Plant measurements, including plant height and diameter, were also recorded at the end of June and July.

The main evaluation in late August was performed by a core team of six individuals. Flower number, flower quality, foliage, plant habit, and an overall plant rating were based on a 1 to 5 scale (1 = not acceptable, 5 = exceptional). Partial results of that evaluation are presented here in Table 2. The table is ranked in descending order of the August 30 overall rating. Plants were monitored throughout the fall and left in ground to observe any possible cold tolerance.

We would like to acknowledge our Annuals Team of Master Gardeners and Chadwick Arboretum Volunteers who assisted in all phases of cultivar trials this season.

Table 1. Cuphea Species Trial

Source	Number of Accessions
Ornamental Plant Germplasm Center (OPGC), Columbus, Ohio	19
North Central Regional Plant Introduction Station (NCRPIS)-USDA/ARS, Ames, Iowa	14
Dr. Shirley Graham, Kent State University, Kent, Ohio	8
Industry:	
Possum Run Greenhouses, Timbuk Farms, Park Seed, Select Seed	12

Table 2. The Top 25 Cuphea Species from The Ohio State University Summer 2002 Trial.

Source	Species	Cultivar/P.I. #	Overall 20-Jun	Flower Overall 20-Jul	Flower Number 30-Aug	Quality	Overall
OPGC	*C.* sp.	Ames 23677	4	4.5	4.75	2.75	4.5
Select Seed	*C. ignea*	David Verity	4	5	4.25	3.5	4.5
OPGC	*C.* hybrid	Ames 22422	4	3.25	3.75	5	4.5
OPGC	*C. micropetala*	Ames 26109	4	4	2	4.25	4.5
OPGC	*C.* sp.	Ames 23826	4	4	2	4	4.25
Possum Run Grnhse.	*C. hyssopifolia*	Star White	4	4	4	3	4
Timbuk Farms (Ball)	*C.* x *purpurea*	Firecracker	4	4	3.5	4.5	4
OPGC	*C.* hybrid	Ames 22423	3.75	3	3.5	4	4
OPGC	*C.* hybrid	Ames 22287 Starfire	4.5	4.5	3	3.5	4
OPGC	*C. hyssopifolia*	Alyson (from Possum Run)	4.5	4.25	2.5	3	4
Dr. Shirley Graham	*C. glutinosa*		2	3	4	3.5	3.5
OPGC	*C.* hybrid	Ames 22431	4	4.25	3.5	3	3.5
OPGC	*C. ignea*	(from Possum Run))	3.75	3.75	3	3.5	3.5
Timbuk Farms (Ball)	*C.* hybrid	Purple Trailing	2.75	3	3	3	3.5
USDA/ARS-NCRPIS	*C. varia*	PI 607939	4	3.75	4	3.5	3.25
USDA/ARS-NCRPIS	*C. ignea*	PI 534826	3	3	3	3.5	3.25
OPGC	*C.* hybrid	Ames 22432	3.5	3	2	2	3.25
Possum Run Grnhse.	*C. hyssopifolia*	Burgundy	3.5	4	4	2.75	3
OPGC	*C. cyanea*	Ames 4946	2.5	2	4	3.5	3
OPGC	*C.* hybrid	Ames 22425	3.5	2	3.5	3.5	3
USDA/ARS-NCRPIS	*C. glutinosa*	PI 596732	3	2.5	3.25	3	3
Possum Run Grnhse.	*C. hyssopifolia*	Lilac	4	3.5	3	3	3
USDA/ARS-NCRPIS	*C. llavea*	PI 534698	1.5	2.75	3	3	3
OPGC	*C.* hybrid	Ames 22421	3	2.5	2.5	4	3
USDA/ARS-NCRPIS	*C. palustris*	Ames 17817	4	4.5	1	1.5	3

Ranked in order of 8/30 overall rating. Rating scale of 1 to 5 with 1 = not acceptable and 5 = exceptional.

Results

2001 - 2002 Pansy and Viola Cultivar Trial

This was the second year for our Fall Pansy and Viola Trials. A total of 98 cultivars were evaluated — 80 pansies and 18 violas. Seed from participating breeders and distributors was sent to Bob Barnitz of Bob's Market and Greenhouse, Mason, West Virginia, for sowing and growing on. This same greenhouse grew the plants for our previous trial. Plants were received in Columbus on 9-11-01 and received a drench of Rootshield the following day.

The trial area consisted of six raised soil beds in a full sun exposure. Violas were transplanted into one bed on 9-18-01. Pansies were transplanted into five beds on 9-25-01. Ten well-developed plants per cultivar were set out at approximately 1 foot spacing. No mulch was used. Plants were fertilized on 10-16-01 with 20-10-20 @ 200 ppm N.

Evaluations were performed throughout the trial period by our core team of evaluators. In the fall, ratings were performed on 10-25-01 and 11-14-01. Mid-winter and post-winter evaluations took place on 1-31-02 and 3-28-02, respectively.

The spring and final rating was done on 4-24-02. At this time, the trial plants were also evaluated by Master Gardener volunteers and departmental staff.

Plants were rated on a 1 to 5 scale with 1 = not acceptable and 5 = exceptional. Criteria included flower number / aesthetics, health and appearance of foliage, plant uniformity, and overall appearance.

Results of the fall pansy and viola evaluation can be seen in Table 3 and Table 4, respectively. The Spring 2002 results are presented in Table 5 and Table 6, respectively.

The trial was well received by the public and local media. Plants were in excellent condition at the time they were pulled on 5-14-02 to make way for our Summer Annuals Trial.

Due to an extremely mild winter, there was color virtually throughout the trial period. Plants were in full bloom until December 24 when the first hard freeze occurred. Some color was displayed throughout January and February, mainly by the Violas. By March, most cultivars were back in bloom, and a vibrant splash of color was available throughout April and into mid-May, when the trial ended.

We would like to acknowledge the assistance of Marcia Feller, David Snodgrass, and participating volunteers and staff members as well as Bob Barnitz.

Table 3. Top 22 Cultivars from The Ohio State University 2001-02 Pansy Trial: Fall 2001.

PANSIES

Series	Cultivar	Seed Company	Flower	Flower Number	Vigor	Overall
EXP	Marina	PanAmerican	4	5	3.75	4.5
EXP-Bingo	Rose & White	PanAmerican	4.75	5	4	4.5
Bingo	White Clear	PanAmerican	4	3.5	3	4
Delta	Fire X Pansy	Syngenta	4	3.75	3.25	4
EXP	Purple Face	PanAmerican	4	4	4	4
Baby Bingo	Lavender Blue	PanAmerican	4	3.75	3.75	3.75
Bingo	Blue Frost	PanAmerican	4	3.5	3	3.75
EXP	Blue Blotch	PanAmerican	4	4	3.5	3.75
Fama	Primrose	Benary	4	3.75	3.5	3.75
Fama	See Me	Benary	3.75	3	3.5	3.75
Atlas	Blue	Bodger	3.5	3.25	3	3.5
Bingo	Red & Yellow	PanAmerican	4.25	3	3	3.5
Delta	Red w/ Blotch	Syngenta	3.5	3.5	2.75	3.5
Experimental	Pure Violet	Syngenta	4	3.5	3	3.5
Fama	Purple	Benary	3	3	3.75	3.5
Fama	Silver Blue	Benary	4	3	3.5	3.5
Happy Face	Beacosfield	Bodger	3.5	3	2.75	3.5
Happy Face	Blue	Bodger	3.5	3.25	3.25	3.5
Karma	Yellow	Goldsmith	3.75	3.5	3	3.5
Majestic Giants II	Blue Cap	Sakata	3.5	2.5	3	3.5
Panola- 7PNL	Yellow	Waller	4	3	3.25	3.5
Happy Face	Mix	Bodger	3	3	3.25	3.25

Fall Evaluation — November 14, 2001.
Results in Order of Overall Ranking. Averages based on a 1 to 5 rating scale with 1 = not acceptable and 5 = exceptional.

Table 4. Overall Ranking of Cultivars from The Ohio State University 2001-02 Viola Trial: Fall 2001.

VIOLAS

Series	Cultivar	Seed Company	Flower	Flower Number	Vigor	Overall
Penny	Yellow Jump-Up	Goldsmith	3.75	3.25	4	3.75
Sorbet	Beaconsfield	Waller	3.75	3.75	4	3.75
Baby Face	Ruby & Gold	Waller	3.75	3.25	3.5	3.5
Sorbet	Black Duet	Waller	3.75	3.5	3.75	3.5
Penny	Deep Blue	Goldsmith	3.5	3.25	3.25	3.25
Penny	Flare	Goldsmith	3	2.75	3.75	3.25
Penny	Azure Wing	Goldsmith	3.25	3	3.5	3.25
Baby Face	Light Blue & White	Waller	3	3	3	3
Sorbet	Antique Shades	Waller	3.5	3	3	3
Sorbet	Red Wing	Waller	3	2.75	3.25	3
Sorbet	Sunny Royale	Waller	3	2.75	3.5	3
Baby Face	White	Waller	3	2.5	2.75	2.75
Baby Face	Yellow	Waller	2.75	3	3	2.75
Penny	Violet Beacon	Goldsmith	2.5	2.5	2.75	2.75
Penny	Yellow	Goldsmith	3	3	2.75	2.75
Sorbet	Black Delight	Waller	3.25	2.75	3.25	2.75
Sorbet	Lilac Ice	Waller	2.75	3	2.75	2.75
Penny	White	Goldsmith	2.5	2.75	2.5	2.5

Fall Evaluation — November 14, 2001.
Results in Order of Overall Ranking. Averages based on a 1 to 5 rating scale with 1 = not acceptable and 5 = exceptional.

Table 5. Top 22 Cultivars from The Ohio State University 2001-02 Pansy Trial: Spring 2002.

PANSIES

Series	Cultivar	Seed Company	Flower	Flower Number	Vigor	Overall
Baby Bingo	Lavender Blue	PanAmerican	5	4.5	5	4.75
EXP	Purple Face	PanAmerican	5	4	4.5	4.5
Clear Sky	Purple X Pansy	Syngenta	4	4	4	4
EXP	Blue Blotch	PanAmerican	4.25	3.75	3.75	4
Fama	Silver Blue	Benary	4	3.5	4.5	4
Panola	w/ Blotch	Waller	4	3.75	4	4
	Purple Rain	PanAmerican	4	4.25	4.5	3.75
Atlas	Blue	Bodger	3.5	3.5	4	3.75
EXP	Marina	PanAmerican	4	3.75	3.75	3.75
Fama	Purple	Benary	3.5	4.25	3.75	3.75
Baby Bingo	All Season's Mix	PanAmerican	3.75	3	3	3.5
Baby Bingo	Fire	PanAmerican	3.5	3.5	4	3.75
Bingo	Blue Frost	PanAmerican	5	3	2.5	3.5
Bingo	Red & Yellow	PanAmerican	4.25	3.75	3.25	3.5
EXP-Bingo	Rose & White	PanAmerican	3.5	3	4	3.5
Fama	See Me	Benary	4	2.5	3	3.5
Majestic Giants II	Blue Cap	Sakata	4	4	3.5	3.5
Majestic Giants II	Ocean	Sakata	4.25	3	3	3.5
Panola-7PNL	Yellow	Waller	3.5	3.5	3.5	3.5
Bingo	Azure Clear	PanAmerican	3.5	3.25	3.25	3.25
Fama	Primrose	Benary	3.25	3.25	3.5	3.25
Fama	True Blue	Benary	3.25	3.25	4	3.25

Spring Evaluation — April 24, 2002.
Results in Order of Overall Ranking. Averages based on a 1 to 5 rating scale with 1 = not acceptable and 5 = exceptional.

Table 6. Overall Ranking of Cultivars from The Ohio State University 2001-02 Viola Trial: Spring 2002.

VIOLAS

Series	Cultivar	Seed Company	Flower	Flower Number	Vigor	Overall
Penny	Flare	Goldsmith	4.25	4.5	4.5	4.5
Penny	Violet Beacon	Goldsmith	4.25	3.75	5	4.5
Penny	Yellow Jump-up	Goldsmith	4.25	4	5	4.5
Baby Face	Ruby & Gold	Waller	4	4.5	4.5	4.25
Penny	Azure Wing	Goldsmith	4.25	4	4	4.25
Sorbet	Beaconsfield	Waller	4.75	4	5	4.25
Baby Face	Yellow	Waller	4	4	3.5	4
Sorbet	Red Wing	Waller	3.5	3.75	5	4
Sorbet	Sunny Royale	Waller	4	4	3.75	4
Baby Face	Light Blue & White	Waller	4	2.75	4.5	3.75
Baby Face	White	Waller	3.75	2.75	5	3.75
Penny	Deep Blue	Goldsmith	4	4	3	3.5
Sorbet	Black Delight	Waller	4	3	3.5	3.5
Sorbet	Lilac Ice	Waller	3.5	3.25	5	3.5
Penny	White	Goldsmith	3	3	4.5	3.25
Penny	Yellow	Goldsmith	3.5	3.5	3	3.25
Sorbet	Antique Shades	Waller	3	2.75	2.75	2.75

Spring Evaluation — April 24, 2002.

Results in Order of Overall Ranking. Averages based on a 1 to 5 rating scale with 1 = not acceptable and 5 = exceptional.

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A Collection of Crabapple Knowledge from Secrest Arboretum: 1993-2002

Erik A. Draper, James A. Chatfield and Kenneth D. Cochran

Introduction

The diversity and versatility of ornamental crabapples are useful to landscape designers in creating specific effects in the landscape. Crabapple tree forms range from small rounded shade trees to spreading weepers. Bud and flower colors create a welcome and popular springtime attraction.

The fruit effect develops as the fruit ripens in summer and fall and persists as long as the colored fruit clings to the branches, on many trees, all the way into winter.

In order to select the proper tree for the emphasis or desired effect, a profile of total aesthetics for each crabapple is necessary. Total aesthetics includes the overall impact of fruit, flowers, foliage, tree form, growth rate of each crabapple selection, and the effects of pests and diseases.

Forty-six crabapple taxa (the original Crablandia plot) growing at the Secrest Arboretum on The Ohio State University's Ohio Agricultural Research and Development Center Wooster, Ohio, campus were evaluated monthly from August 1993 to August 2000. An additional 14 crabapple taxa were added and evaluated there from August 1997 to August 2000.

A new Crablandia II plot at Secrest Arboretum, which presently includes 65 taxa, was established in 1998, and evaluations began in June 2001.

The results of these evaluations are presented in this report, which is intended for use by nurseries, garden centers, landscape architects, landscapers, and homeowners. This information can assist in providing an accurate profile of each tree's features within the specific growing conditions of northeastern Ohio.

Materials and Methods

The original crabapple research plot at Secrest, designated as Crablandia, had a completely randomized design with three single-plant replicates of each taxon. This National Crabapple Evaluation Plot (NCEP), planted in 1984, contained 46 crabapple taxa. Observations and data were collected on each of these 46 taxa.

However, due to disease, attrition, and repeatedly poor performance, some crabapple selections were culled in 1998. The remaining 28 crabapple taxa provided data in Crablandia through August 2000.

Erik A. Draper, Ohio State University Extension, Geauga County; James A. Chatfield, Ohio State University Extension, Northeast District/Horticulture and Crop Science; and Kenneth D. Cochran, Secrest Arboretum of The Ohio State University, Ohio Agricultural Research and Development Center, and Ohio State University Extension.

An additional 14 crabapple selections were interplanted into the original NCEP plot in 1994 and rated from August 1997 to August 2000 only.

A second crabapple research plot, designated as Crablandia II, was initiated in 1998 at Secrest Arboretum. It began with 58 selected crabapple taxa. This plot consists of a completely randomized design, with five single-plant replicates of each taxon. Planting of the additional selections or new releases will be on an ongoing basis. Research evaluations and data collection in Crablandia II began in June 2001.

Fruit color and size, bloom color, tree form, incidence of scab, and mature tree size for all the crabapples evaluated in Crablandia and Crablandia II are reported in Table 1. These findings were cross referenced with tree size, fruit size, and fruit color observations recorded by the late crabapple hybridizer, Father John Fiala (4) and other researchers (2). Apple scab susceptibility ratings and aesthetic observations from the Secrest plots were recorded yearly, during the months of June through August; those findings were compiled for this report.

Table 2 provides the time of effective fruit display, overall mature tree size, and an expanded description or profile of each crabapple taxon. These profiles offer the positive and negative aspects of aesthetics and disease observations, according to the evaluations of the authors (1, 3). The time of effective fruit display was compiled from observations conducted each month during the year.

The overall disease observations were compiled from findings noted and reported by the authors in other articles written for previous publications of this ornamental research circular (1). Aesthetic and apple-scab ratings over the period of this research were recorded on 1 to 5 and 0 to 5 rating scales and are available elsewhere (1, 3), but are not itemized here due to space and format considerations.

Results and Discussion

The 2002 growing season was difficult because of weather extremes. Spring rains were abundant and the ground was saturated for extended periods of time. At the end of May, the rains stopped, and hot, dry weather remained until late September, making 2002 a good year to add evaluations of tree response to drought stress.

Due to the plentiful periods of cool, wet weather in the spring, the crabapples were challenged by ideal conditions for apple scab *(Venturia inaequalis)* development. This year was also an "off" or light year for fruit because of the unusually heavy fruit set of 2001.

Perfect weather during the 2001 bloom caused most flowers to emerge unscathed by frost and consequently, most flowers set fruit. The result was a spectacular year for fruit in 2001, but the heavy fruit development limited the amount of carbohydrates available for flower-bud initiation. Therefore, flower display, and accordingly fruit display, were limited in 2002.

Table 1. Fruit Color, Fruit Size, Bloom Color, Tree Form, Scab Rating, and Mature Tree Size of Crabapples at Secrest Arboretum.

Crabapple	Fruit Color[1]	Fruit Size (Inches)	Bloom Color[2]	Tree Form[3]	Scab Rating[4]	Mature Tree Size[5]
'Adams'	MR	0.5 - 0.75	DP	MS	major	20
'Adirondack'	OR	0.4 - 0.6	W	NU	none	15
'American Masterpiece'	YO	0.3 - 0.5	RP	BR	major	18
'American Salute'	RO	0.3 - 0.5	RoPu	US	minor	28
'American Spirit'	MR	0.4 - 0.5	RoP	BR	major	18
'American Triumph'	M	0.3 - 0.4	RoP	BR	major	18
Malus baccata 'Jackii'	MR	0.4 - 0.5	W	BR	none	25
'Beverly'	RoR	0.5 - 0.75	W	BS	none	20
'Bob White'	GY	0.4 - 0.5	W	BR	none	20
'Brandywine'	YGr	1 - 1.5	DP(db)	MS	minor	20
'Callaway'	CR	0.75 - 1.2	W	MS	none	18
M. zumi 'Calocarpa'	DR	0.3 - 0.4	W	MS	trace	15
'Camelot'	RoP	0.3 - 0.4	W	DR	trace	10
'Canary'	Y	0.25 - 0.4	W	UO	minor	18
'Candymint'	RPu	0.25 - 0.4	RoP	LS	trace	8
'Canterbury'	RoP	0.25 - 0.4	P	DR	none	10
'Centurion'	CR	0.4 - 0.6	RoR	US	major	20
'Cinderella'	GY	0.2 - 0.3	W	DR	trace	6
'Coralburst'	YGr	0.2 - 0.3	CoP (db)	R	minor	15
'David'	CR	0.5 - 0.6	W	R	trace	15
'Dolgo'	RPu	1 - 1.5	W	MS	none	18
'Donald Wyman'	R	0.4 - 0.5	W	BR	minor	25
'Doubloons'	LG	0.4 - 0.5	W(db)	R	minor	12
'Excalibur'	GY	0.2 - 0.3	W	DR	none	10
'Firebird'	RO	0.2 - 0.3	W	DU	none	10
M. floribunda	Y	0.3 - 0.4	W	BR	trace	15
'Foxfire'	CR	0.5 - 0.6	W	BR	none	15
'Glen Mills / Winter Gem'	R	0.2 - 0.3	W	OV	major	18
'Golden Raindrops'	Y	0.2 - 0.3	W	OS	none	22
'Guinevere'	CR	0.5 - 0.6	W	DO	none	8
'Hamlet'	MR	0.4 - 0.5	W	DM	none	10
'Harvest Gold'	Y	0.3 - 0.4	W	BR	major	20
'Henningii'	RO	0.5 - 0.6	W	UO	major	25
'Holiday Gold'	GY	0.4 - 0.5	W	OS	none	18
M. adstringens 'Hopa'	R	0.6 - 0.8	RoR	US	major	25
'Indian Magic'	OR	0.3 - 0.4	RoP	MS	major	15
'Indian Summer'	R	0.5 - 0.6	RoR	BR	major	18
'Jewelberry'	RO	0.3 - 0.4	W	DB	major	8
'King Arthur'	RoR	0.5 - 0.6	W	DM	none	12
'Lancelot'	Y	0.2 - 0.3	W	DU	none	10
'Lollipop'	RO	0.2 - 0.3	W	DR	none	8
'Liset'	MR	0.5 - 0.6	RoR	OR	trace	15
'Louisa'	LG	0.3 - 0.4	P	TW	none	15
'Madonna'	BrR	0.4 - 0.5	W(db)	US	major	20
'Manbeck's Weeper'	CR	0.3 - 0.4	W	SW	minor	8
'Mary Potter'	R	0.3 - 0.4	W	OS	trace	10
'Molten Lava'	RO	0.3 - 0.4	W	MS	minor	15
'Narrangansett'	CR	0.4 - 0.5	W	MS	major	12
'Ormiston Roy'	OY	0.3 - 0.4	W	BR	trace	20
M. halliana 'Parkmanii'	Y	0.3 - 0.4	W	BR	minor	15
'Pink Princess'	MR	0.2 - 0.3	RoP	DM	trace	8

Table 1 (continued). Fruit Color, Fruit Size, Bloom Color, Tree Form, Scab Rating, and Mature Tree Size of Crabapples at Secrest Arboretum.

Crabapple	Fruit Color[1]	Fruit Size (Inches)	Bloom Color[2]	Tree Form[3]	Scab Rating[4]	Mature Tree Size[5]
'Pink Satin'	DR	0.3 - 0.4	P	UO	major	12
'Prairie Maid'	RoR	0.3 - 0.4	DP	BS	none	10
'Prairifire'	RPu	0.4 - 0.5	CoR	OR	trace	18
'Professor Sprenger'	OR	0.5 - 0.6	W	MS	minor	20
'Profusion'	MR	0.4 - 0.5	RPu	US	major	22
'Purple Prince'	BPu	0.4 - 0.5	RoR	BR	trace	15
'Radiant'	RPu	0.4 - 0.5	DP	MS	major	25
'Ralph Shay'	R	1.3- 1.5	W	BS	major	10
'Rawhide'	R	1.2- 1.5	W	NU	none	18
'Red Barron'	DR	0.5 - 0.6	RP	US	major	18
'Red Jade'	R	0.4 - 0.5	W	SW	minor	12
'Red Jewel'	CR	0.3 - 0.4	W	OV	trace	15
'Red Splendor'	R	0.5 - 0.6	RoP	US	major	20
'Red Swan'	R	0.2 - 0.3	WhP	TW	trace	10
'Robinson'	DR	0.5 - 0.6	RoPu	MS	major	25
'Royal Fountain'	MR	0.2 - 0.3	RoP	TW	minor	10
'Royal Scepter'	CR	0.5 - 0.6	RoP(db)	US	major	18
'Royalty'	DR	0.5 - 0.6	RPu	MS	major	15
'Ruby Luster'	RoR	1.5- 1.7	RoP	BR	major	28
M. sargentii	R	0.2 - 0.3	W	LS	none	8
'Selkirk'	CR	0.9 - 1.0	RoR	BR	major	20
'Sentinel'	R	0.3 - 0.4	W	US	minor	18
'Silver Drift'	CR	0.3 - 0.4	W	OV	minor	20
'Silver Moon'	RPu	0.3 - 0.4	W	MS	none	20
'Sinai Fire'	RO	0.4 - 0.5	W	OS	none	15
'Snowdrift'	SR	0.3 - 0.4	W	BR	minor	20
'Spring Snow'	No Fruit	No Fruit	W	OV	major	25
'Strawberry Parfait'	R	0.4 - 0.5	P	OS	trace	18
'Sugar Tyme'	CR	0.4 - 0.5	W	MS	minor	18
'Thunderchild'	BPu	0.3 - 0.4	RoR	OV	major	15
M. sargentii 'Tina'	RPu	0.2 - 0.3	W	LS	none	5
M. tschonoskii	YGr	1- 1.2	W	PY	none	35
'Velvet Pillar'	MR	0.4 - 0.5	P	US	major	20
'Weeping Candied Apple'	R	0.4 - 0.5	RoP	OS	major	15
'White Angel'	R	0.5 - 0.6	W	BR	none	20
'White Cascade'	YGr	0.3 - 0.4	W	TW	major	15
'Winter Gold'	LG	0.3 - 0.4	W	UO	major	25

[1] Fruit Color Key — Bpu: blue-purple; BrR: brown-red; CoR: coral-red; CR: cherry-red; DP: deep pink; DR: dark red; G: gold; G: golden-yellow; LG: lemon-gold; M: maroon; MR: maroon-red; O: orange; OR: orange-red; OY: orange-yellow; P: pink; Pu: purple; R: red; RO: red-orange; RPu: red-purple; Ro: rose; RoR: rose-red; SR: salmon red; Y: yellow; YGr: yellow-green.

[2] Bloom Color Key — (db) Signifies that the bloom is a double flower; CoR: coral-red; CoP: coral-pink; P: pink; DP: deep pink; R: red; RP: red-pink; RPu: red-purple; Ro: rose; RoP: rose-pink; RoR: rose-red; RoPu: rose-purple; W: white; WhP: white-pink.

[3] Tree Form — BR: broadly rounded; BS: broadly spreading; DR: dwarf rounded; DB: dwarf broadly rounded; DM: dwarf mounded spreading; DO: dwarf open spreading; DU: dwarf upright spreading; LS: low spreading; MS: mounded spreading; NU: narrow upright; OS: open spreading; OR: open rounded; OV: oval; R: rounded; SW: spreading weeper; TW: true weeper; UO: upright open; US: upright spreading.

Table 1 (continued). Fruit Color, Fruit Size, Bloom Color, Tree Form, Scab Rating, and Mature Tree Size of Crabapples at Secrest Arboretum.

[4] Scab ratings are compiled from previous observations, as well as individual taxa ratings for apple scab, recorded yearly during the months of June through September, the principal period for disease expression by the apple scab fungus.

None = no scab noted.
trace = a few leaves affected; no negative effect on aesthetics.
minor = 20% to 50% of leaves affected; significant defoliation and/or leaf yellowing; negative effect on aesthetics.
major = 50% to 90% of leaves affected; severe defoliation and discoloration of leaves; almost complete negation of any aesthetic effect.

[5] Tree height is expressed in feet.

Table 2. Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Adams'	**mid-July to late December** Maroon-red fruits, deep pink flowers, rounded form.	**18-20**
Positives: Abundant oval shaped fruit; attractive striated bark on upper trunk and branches; nice yellow fall color; fast-growing tree. **Negatives:** Tenacious fruit mummies may remain for up to two years; mummies may detract from aesthetics during bloom and summer appearance; chlorotic foliage noted during summer. **Diseases:** Major leaf scab.		
'Adirondack'	**late August to mid-December** Orange-red fruits, white flowers, narrow upright form.	**12-15**
Positives: One of the best for tight, columnar form; great autumn fruit/foliage combination; fruit ripens to a deep orange-red; fruit appears singular rather than clustered; annual consistent flowers are red-tinged. **Negatives:** Somewhat slow to establish and grow; leafhoppers appear to relish the foliage but no apparently harm from the feeding. **Diseases:** No scab.		
'American Masterpiece'	**late August to mid-November** Yellow-orange fruits, red-pink flowers, broadly rounded form.	**18-20**
Positives: Large, spectacular flowers. **Negatives:** Very susceptible to scab; an intense scab season may totally defoliate the tree by late July. **Diseases:** Major fruit and leaf scab.		
'American Salute'	**mid-August to late November** Red-orange fruits, rose-purple flowers, upright spreading form.	**25-28**
Positives: Great autumn fruit/foliage combination; fall foliage color ranges from reds to apricot and oranges; fruit ripens to a deep red-orange; fruit can line branches creating an outstanding fruit display; very fast growing tree. **Negatives:** Develops into a very large tree; scabby leaves remain on the tree; very susceptible to scab. **Diseases:** Major leaf scab.		
'American Spirit'	**late August to mid-December** Maroon-red fruits, rose-pink flowers, rounded form.	**15-18**
Positives: Great flower display when blooming; fruit with oblong shape. **Negatives:** Somewhat slow to establish and grow; very susceptible to scab; an intense scab season may defoliate the tree by mid-August. **Diseases:** Major scab.		
'American Triumph'	**mid-September to late January** Maroon fruits, rose-pink flowers, broadly rounded form.	**18-20**
Positives: Attractive flower display when blooming. **Negatives:** Very susceptible to scab; an intense scab season may defoliate the tree by late July. **Diseases:** Major scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
Malus baccata 'Jackii'	**mid-August to late January** Maroon-red fruits, white flowers, broadly rounded form.	18-20

Positives: Reliable flower display; large, glossy green leaves, by far the best foliage of any crabapple in the plot; outstanding fall contrast of yellow- to rust-colored leaves against attractive maroon-red fruit; frosty temperatures cause bark to take on an orange cast. **Negatives:** Relative sparseness of fruit clusters and mediocre overall winter appearance. **Diseases:** No scab.

'Beverly'	**late July to mid-October** Bright pinkish-red fruits, white flowers, broadly rounded form.	18-20

Positives: Consistent flowers; impressive fruit display from late summer through early fall; profuse pink buds opening to snowy white flowers in spring. **Negatives:** Muddied, rotted fruits turn black beginning mid-fall through winter; fruits partially eaten by birds creating an unsightly mess on the tree; sprawling, awkward growth habit. **Diseases:** No scab; however, moderate fireblight noted in 1994.

'Bob White'	**mid-October to late January** Gold-yellow fruits, white flowers, broadly rounded form.	18-20

Positives: Persistent, small, firm fruits maturing mid-winter into striking orange-gold color; an excellent fruit color for fall and winter landscapes; exceptional floral display of delicate white blossoms mixed with pinkish-red buds; overall one of the better yellow-fruiting selections of the plot. **Negatives:** Fruit/floral display alternates yearly from profuse to sparse; lacks summer appeal due to inconspicuous green fruit color. **Diseases:** No scab.

'Brandywine'	**mid-June to late October** Yellow-green fruits, deep-pink double flowers, rounded form.	18-20

Positives: Double flower is without equal; fragrant, deep-pink flowers look like tiny roses; great fall foliage color; large leaves with burgundy overtones; great smooth, silver-colored bark. **Negatives:** Very large fruit; slow to establish and grow; cedar-apple rust may disfigure leaves in some areas. **Diseases:** Minor fruit and leaf scab.

'Callaway'	**late August to mid-November** Cherry-red fruits, white flowers, broadly rounded form.	18-20

Positives: Lovely white flowers; shiny cherry-red fruits; large green, scab-resistant foliage. **Negatives:** Large fruited crabapple; a heavy fruit set can disfigure tree by loading down young branches. **Diseases:** No scab.

M. zumi 'Calocarpa'	**late-August to mid-December** Red fruits, white flowers, broadly rounded form.	15-18

Positives: Consistent annual flower display; abundant clusters of tiny, petite, shiny red fruit; attractive red pedicel effect created after the fruit falls off. **Negatives:** Fruits shrivel rapidly after a few frosts; overall winter appeal is limited. **Diseases:** Minor leaf and trace of fruit scab.

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Camelot'	**mid-July to late October** Rose-pink fruits, white flowers, dwarf rounded form.	**8-10**
Positives: Oblong, unique colored fruit; petite, lovely fuschia-tinged flower; diminutive size is great for space limited areas; foliage dark green with burgundy overtones. **Negatives:** Very slow growing; dull summer leaf appearance. **Diseases:** No scab.		
'Canary'	**mid-August to mid-November** Yellow fruits, white flowers, upright open form.	**12-15**
Positives: Bright yellow, tiny fruits hang in clusters along branches to accentuate open form; good autumnal fruit/foliage combination creates a blaze of yellow; cider brown fruit generates aesthetic interest in a fall with mild temperatures. **Negatives:** Early defoliation from scab; fruit deteriorates rapidly to cider brown and falls off quickly after a few frosts. **Diseases:** Minor leaf and trace of fruit scab.		
'Candymint'	**mid- July to late November** Red-purple fruits, pink flowers, low spreading form.	**8-10**
Positives: Graceful low spreading form; reliable fruit/flower displays; burgundy-tinged leaves; new stems are a deep burgundy; new foliage is striking, shiny wine-red. **Negatives:** Very slow growing; fruit display is never overwhelming; dull summer leaf appearance. **Diseases:** Trace of leaf scab.		
'Canterbury'	**mid-July to late October** Rose-pink fruits, white flowers, rounded form.	**8-10**
Positives: Attractive oblong fruit; petite, lovely fuschia-tinged flower; diminutive size is great for space limited areas; foliage dark green with burgundy overtones. **Negatives:** Very slow growing; dull summer leaf appearance. **Diseases:** No scab.		
'Centurion'	**mid-June to late October** Cherry-red fruits, rose-red flowers, upright spreading form.	**18-20**
Positives: Attractive blossom show; nice glossy new fruit; fall foliage colors to a rust-orange. **Negatives:** Fruits dull with age; awkward appearance of open splayed branches as tree matures. **Diseases:** Major leaf and trace of fruit scab.		
'Cinderella'	**late August to mid-November** Golden-yellow fruits, white flowers, dwarf rounded form.	**4-6**
Positives: Snowy-white flower display; tiny fruits start yellow and mellow to golden hue; diminutive tree form excellent for restricted spaces. **Negatives:** Fruit hidden and unnoticed until leaf drop; fruit quickly turns cider brown with warmer temperatures; mediocre summer appeal. **Diseases:** Trace of scab; apple mosaic virus noted.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Coralburst'	**early October to early November** Yellow-green fruits, coral-pink double flowers, dense-rounded form.	**12-15**
Positives: Tree form is consistent and easy to identify; double flowers can be showy. **Negatives:** Fruit hidden and unnoticed until leaf drop; fruit rarely noticed due a type of fruit russeting and same color as leaves; strap-like leaves are very susceptible to scab. **Diseases:** Major scab.		
'David'	**mid-September to mid-November** Scarlet fruits, white flowers, rounded form.	**12-15**
Positives: Abundant snowy-white flower display; impressive cherry-like fruits; nice tree form. **Negatives:** yearly floral/fruit displays alternate from profuse to sparse; large mummies hang from late fall to mid-winter; mediocre summer appeal. **Diseases:** Trace of scab.		
'Dolgo'	**early August to mid-September** Red-purple plum-like fruits, snowy-white flowers, large rounded form.	**15-18**
Positives: Consistent, very early annual bloomer; almost neon red-purple fruits are edible and great for jam and jellies; fruit impressive for a brief period during mid-summer. **Negatives:** Major fruit mess due to fruit drop; overripe fruit smell is intoxicating and attractive to yellowjackets; lacks ornamental effect for much of the year. **Diseases:** No scab.		
'Donald Wyman'	**mid-September to late March** Bright red fruits, white flowers, broadly rounded form.	**22-25**
Positives: Excellent floral display; persistent glossy fruits remain effective, turning mud-red after a freeze; attractive exfoliating bark develops on mature trees. **Negatives:** Tenacious fruit mummies hang into early summer; heavy fruit scab repeatedly reduces overall appeal. **Diseases:** Minor leaf and major fruit scab.		
'Doubloons'	**early October to mid-December** Lemon-gold fruit, white double flowers, rounded form.	**10-12**
Positives: Double flowers are gorgeous with carmine tinted outer petals contrasting with inner silky-white petals; lemon-yellow fruit mellows to gold with each frost. **Negatives:** Slow to establish and grow; mediocre appeal for most of the growing season until leaves drop. **Diseases:** Minor leaf and trace of fruit scab.		
'Excalibur'	**mid-September to mid-December** Golden-yellow fruit, white flowers, dwarf rounded form.	**8-10**
Positives: Consistent rounded tree form; tiny, small, shiny fruit is outstanding in the fall; fruit-lined branches create striking specimen in the landscape; fruits mature to a shiny cider brown color but interest still retained. **Negatives:** Flowers can be hidden by rapidly expanding foliage; fruit is hidden to the plant interior until leaves drop. **Diseases:** No scab; apple mosaic virus noted.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Firebird'	**mid September to late January** Red-orange fruit, white flowers, dwarf upright spreading form.	**8-10**
Positives: Consistent tree form is achieved by top grafting (high graft) and is perfect for restricted spaces; small fruit matures to deep red; good flower display. **Negatives:** Slow to establish and grow; flower and fruit displays are scattered and steady but never dazzling. **Diseases:** No scab.		
M. floribunda	**mid-October to early November** Yellow fruit, white flowers, broadly rounded form.	**12-15**
Positives: Airy floral display of pink-red buds opening to white flowers; great commingling of yellow and cider-brown fruit colors for autumnal effect; fruit may develop a red blush; feathery effect of pedicels in winter. **Negatives:** Yellow flecking of foliage in summer; very short time of fruit impact; relatively ordinary appearance for much of the year. **Diseases:** Minor scab.		
'FoxFire'	**early September to mid-November** Cherry-red fruit, white flowers, broadly rounded form.	**12-15**
Positives: fruit has a unique beak or point located on the calyx end; fast-growing tree; consistent form; nice clean foliage; fruit color mellows with each frost. **Negatives:** Mediocre appeal until fruits color; fireblight can be a problem. **Diseases:** No scab; very susceptible to fireblight.		
'Glenn Mills/Winter Gem'	**late August to mid-April** Bright red fruits, white flowers, broadly rounded form.	**15-18**
Positives: Dependable annual bloom; petite, firm, shiny fruit is sensational; long-lasting fruit effect; consistent tree form; fast to establish and grow. **Negatives:** Mediocre summer appeal. **Diseases:** Major leaf and trace of fruit scab.		
'Golden Raindrops'	**mid-October to early December** Yellow fruits, white flowers, open spreading form.	**20-22**
Positives: Petite, lemon-yellow fruits; interesting cutleaf, glossy deep-green foliage; reliable fruit/flower display; great autumnal leaf color; contrasting yellow-orange bark. **Negatives:** Bland green fruit throughout the summer; tree form unruly without pruning. **Diseases:** No scab; very susceptible to fireblight.		
'Guinevere'	**late Aug to mid November** Cherry-red fruit, white flowers, dwarf broadly spreading form.	**6-8**
Positives: Horizontal orientation of branches is interesting aspect; flower and fruit displays are steady annual events but scattered along the branches. **Negatives:** Slow to establish and grow; flower and fruit displays are underwhelming. **Diseases:** No scab; apple mosaic virus noted.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Hamlet'	**late Aug to mid November** Maroon-red fruit, rose-pink flowers, dwarf broadly spreading form.	**8-10**
Positives: Horizontal orientation of branches is interesting aspect; bronze green foliage; flower and fruit displays are steady annual events but scattered along the branches. **Negatives:** Slow to establish and grow; flower and fruit displays are acceptable but never dazzling. **Diseases:** No scab; apple mosaic virus noted.		
'Harvest Gold'	**late October to mid-December** Yellow fruits, white flowers, upright open form.	**18-20**
Positives: Attractive butter-yellow fruits mature to golden yellow; nice contrast of red pedicels against fruit clusters. **Negatives:** Long period of bland green fruit well into mid-fall; leaves hang on for a long time, hiding the fruit; awkward, gangly form; extensive fruit scab. **Diseases:** Major leaf and fruit scab; very susceptible to fireblight.		
'Henning/Henningii'	**late July to late September** Orange-red fruits, white flowers, upright open form.	**22-25**
Positives: Profuse annual flower show; attractive fruit display for brief period. **Negatives:** Awkward, upright gangly form; extensive scab. **Diseases:** Major leaf and fruit scab.		
'Holiday Gold'	**late September to late March** Golden-yellow fruits, white flowers, open spreading form.	**15-18**
Positives: One of the best new, yellow-fruited crabapples in the plot; annual flower show and fruit display is excellent; attractive cream-yellow fruits mellow to golden yellow; rose blush accents nicely yellow fruits; fruits hang in distinct clusters along branches. **Negatives:** Tree form may become awkward due to fruit load. **Diseases:** No scab; trace of fireblight.		
'Hopa'	**fruits ineffective** Red fruits, rose-red flowers, upright spreading form.	**22-25**
Positives: Consistent annual, large blooms. **Negatives:** Scabby fruit never develops color; very early defoliation due to extreme susceptibility to scab; gangly, awkward tree form. **Diseases:** Major leaf and fruit scab.		
'Indian Magic'	**mid-July to early February** Orange-red fruits, rose-pink flowers, mounded spreading form.	**12-15**
Positives: Outstanding fruit display; outstanding autumnal orange-red fruits with golden yellow underside; emerging foliage a pleasing burgundy; fall foliage an apricot-orange color; unfailing pink floral show. **Negatives:** Tenacious fruit mummies; defoliation in mid- to late summer from scab, although fruit scab is minimal. **Diseases:** Major leaf and trace of fruit scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Indian Summer'	**early June to mid-February** Red fruits, rose-red flowers, broadly rounded form.	**15-18**
Positives: Consistent annual, large blooms; prolific mid-summer to fall display of large red fruits; contrasting fruits complement yellow-orange fall foliage. **Negatives:** Persistent fruit mummies; early defoliation from scab. **Diseases:** Major scab.		
'Jewelberry'	**early June to mid-February** Red-orange fruits, white flowers, dwarf broadly rounded form.	**6-8**
Positives: Open, airy, diminutive tree form is its best feature; tiny fruit size complements tree form in years with heavy fruit set. **Negatives:** Alternates yearly from heavy to light flower and fruit display; persistent fruit mummies; early defoliation from scab; some winter injury / dieback observed. **Diseases:** Major leaf and trace of fruit scab.		
'King Arthur'	**mid-September to mid-January** Red-orange fruits, white flowers, dwarf mounded spreading form.	**10-12**
Positives: Fruits artfully scattered along branches; craggy branches and open tree form enhances appearance after leaves drop. **Negatives:** Slow to establish and grow; some tendencies to alternate yearly from heavy to light flower and fruit display. **Diseases:** No scab; apple mosaic virus noted.		
'Lancelot'	**early October to early December** Yellow fruits, white flowers, dwarf upright spreading form.	**8-10**
Positives: Diminutive size is great for space-limited areas; consistent tree form; fruit is a pleasing mix of cider and yellow. **Negatives:** Extremely tight, dense tree form; fruit / flower mostly hidden on the interior of the tree. **Diseases:** Trace of scab; apple mosaic virus noted.		
'Lollipop'	**mid-September to mid-December** Red-orange fruits, white flowers, dwarf rounded form.	**6-8**
Positives: Consistent tree form is achieved by top grafting (high graft) and is perfect for restricted spaces; very tiny fruit matures to red; nice flower display. **Negatives:** Slow to establish and grow; flower and fruit displays are scattered and steady but never dazzling. **Diseases:** No scab.		
'Liset'	**early July to mid-December** Maroon-red fruits, rose-red flowers, open rounded form.	**12-15**
Positives: Consistent flower display; nice fall contrast of fruits with peach colored foliage; new foliage is deep burgundy and matures to a bronze green. **Negatives:** Awkward splayed growth habit; minimal fruit-foliage contrast; fruit mummies hang on until late fall. **Diseases:** Trace of scab. Note: Unusual, but apparently normal, splitting of bark along branches and trunk is characteristic.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Louisa'	**late July to mid-November** Lemon-gold fruits, pink flowers, true weeper form.	**12-15**
Positives: Reliable annual bloom is a true pink; flower display is extraordinary, like pink clouds; arching, graceful branches are upswept at ends; tree form is greatest asset; fruit mellows to a gold-orange with a rose blush accent. **Negatives:** Fruit set is consistently light and scattered, never dazzling. **Diseases:** No scab.		
'Madonna'	**fruits ineffective** Brown-red fruits, double white flowers, upright spreading form.	**18-20**
Positives: Double blooms are sparkling white and fragrant; consistent annual flower display. **Negatives:** Scabby fruit never develops color; very early defoliation due to extreme susceptibility to scab and frogeye leaf spot; tree form can be awkward. **Diseases:** Major leaf and fruit scab; frogeye leaf spot; very susceptible to fireblight.		
'Manbeck's Weeper'	**mid-September to mid-January** Cherry-red fruits, white flowers, spreading-weeping form.	**6-8**
Positives: Exquisite mix of pink buds opening to white blossoms; reliable annual fruit and flower displays; shiny red fruit accents the elegant spreading weeping growth habit; new twig growth is an attractive red color. **Negatives:** Pruning necessary to keep center from becoming too cluttered. **Diseases:** Trace of scab.		
'Mary Potter'	**mid-Aug to mid-November** Red fruits, white flowers, spreading-weeping form.	**8-10**
Positives: Abundant masses of reddish fruit; profuse pink buds open to an blossom display; elegant spreading growth habit; salmon-colored underbark revealed as older bark peels away. **Negatives:** Fruit mummies a distraction during winter months. **Diseases:** Trace of scab.		
'Molten Lava'	**early September to mid-December** Red-orange fruits, white flowers, spreading-weeping form.	**12-15**
Positives: Consistent, profuse flower/fruit shows; fiery red fruits and yellowing fall foliage on cascading branch structure create a "molten lava" effect; excellent winter ratings due to layered horizontal branching; feathery effect created by red pedicels after fruit drops. **Negatives:** Somewhat cluttered as tree matures; lacks summer appeal. **Diseases:** Minor scab.		
'Narrangansett'	**early September to mid-December** Cherry-red fruits, white flowers, upright spreading form.	**10-12**
Positives: Nice flower display; abundant, firm fruit. **Negatives:** Cluttered, dense branching structure; tendency toward alternating sparse and abundant yearly flower displays; awkward tree form. **Diseases:** Major leaf and minor fruit scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Ormiston Roy'	**late August to late March** Orange-yellow fruits, white flowers, broadly rounded form.	**18-20**
	Positives: Very attractive glossy orange-yellow fruits with cream underside and red blush; orangish deep-furrowed bark colors as temperatures drop; consistent annual floral and fruit show. **Negatives:** Tenacious mummified fruit may remain up to one year. **Diseases:** Trace of scab.	
M. halliana **'Parkmanii'**	**mid-October to early November** Yellow fruit, white double flowers, broadly rounded form.	**12-15**
	Positives: Airy floral display of pink-red buds opening to white flowers; great mix of yellow and cider-brown fruit colors for autumnal effect; fruit may develop a red blush; feathery effect of pedicels in winter. **Negatives:** Very short time of fruit impact; relatively ordinary appearance for much of the year. **Diseases:** Minor scab.	
'Pink Princess'	**early June to mid- October** Maroon-red fruits, rose-pink flowers, low spreading form.	**6-8**
	Positives: Unique downswept tree form; very pleasing pink bloom complements tree shape; tiny fruits and small leaves; tree form is its greatest strength. **Negatives:** Burgundy-tinted green leaves turn dull bronze in summer; fruits lost against foliage. **Diseases:** Trace of scab.	
'Pink Satin'	**mid-August to mid-October** Cherry-red fruits, pink flowers, upright spreading form.	**10-12**
	Positives: Very nice, true pink bloom; fruit a pleasing red with yellow underside. **Negatives:** Persistent blackened mummies can be overwhelming; scab can eliminate most fruit color; pruning necessary to reduce cluttered branch structure. **Diseases:** Major leaf and fruit scab.	
'Prairie Maid'	**early July to mid-November** Rosy-red fruits, deep pink flowers, broadly spreading form.	**8-10**
	Positives: Reliable, wonderful flower display; abundant clusters of small fruit; emerging foliage is burgundy red; great autumnal yellow leaf color. **Negatives:** Lacking in winter appeal; waxy coating dulls fruit finish until coating weathers off. **Diseases:** No scab.	
'Prairifire'	**late June to early December** Red-purple fruits, coral-red flowers, open rounded form.	**15-18**
	Positives: Yearly spectacular bloom and fruit displays; blooms contrast newly emerged red-tinted green foliage; firm purplish fruits slowly age to cherry red; fabulous fall colors range the spectrum from red to orange to apricot; unique lenticel-speckled bark. **Negatives:** Mediocre winter and early summer appearance. **Diseases:** Trace of scab.	

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Professor Sprenger'	**late September to mid-December** Orange-red fruits, white flowers, open spreading form.	**18-20**
Positives: Dependable, large, attractive white flowers; large orange-red fruits; young tree form with fruit is stunning. **Negatives:** Mud brown mummies persist until late winter; awkward growth habit and tree form with maturity; dull appearance of large yellow-green fruit during the summer. **Diseases:** Minor scab; defoliation from frog-eye leaf spot.		
'Profusion'	**mid-July to mid-October** Cherry-red fruits, rose-pink flowers, upright spreading form.	**20-22**
Positives: Dependable, very attractive floral display; abundant fruit. **Negatives:** Lack of contrast between purple-bronze colored foliage and fruits and flowers; mediocre winter appeal; rotted fruit and mummies persist until late winter; extensive defoliation from apple scab. **Diseases:** Major scab.		
'Purple Prince'	**late July to mid-November** Blue-purple fruits, rose-red flowers, broadly rounded form.	**12-15**
Positives: Large, dark unusual colored fruit; very nice yearly fruit/flower display; fast-growing tree; leaves deep green with a burgundy tint. **Negatives:** Lacking fruit/foliage contrast; mediocre winter appearance. **Diseases:** Trace of scab.		
'Radiant'	**fruits ineffective** Cherry-red fruits, red-pink flowers, broadly rounded form.	**22-25**
Positives: Beautiful red-pink blossoms; leaves emerge red-purple and fade to bronze; almost neon-red fruit may be evident in late summer. **Negatives:** Total lack of contrast between foliage and fruit and flowers; consistently defoliated from scab; scab causes fruit to be unsightly and unnoticed; mummified fruit can persist for months. **Diseases:** Major leaf and fruit scab.		
'Ralph Shay'	**early September to mid-October** Red fruits, white flowers, broadly spreading form.	**8-10**
Positives: Fruit is edible and tasty; uniform tree shape; red buds open to white flowers. **Negatives:** Large fruit creates an unsightly rot and mess; codling moth fruit damage deforms fruit and causes early fruit drop; scab on fruit can dull appearance. **Diseases:** Major leaf and fruit scab.		
'Rawhide'	**mid-September to late October** Red fruits, white flowers, narrow upright form.	**15-18**
Positives: Unique upright elliptical form; large white flowers emerging from red-pink buds; large shiny green leaves; fast-growing tree. **Negatives:** Very large fruit; fruit only provides a short time of impact. **Diseases:** No scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Red Barron'	**mid-July to late October** Deep red fruits, red-pink flowers, upright spreading form.	**15-18**
Positives: Interesting pumpkin-shaped fruits; exfoliating bark on mature tree trunk. **Negatives:** Tree defoliation due to scab susceptibility; unsightly fruit mummies can persist for two years; gangly, splayed tree form; scab on fruit blackens appearance. **Diseases:** Major leaf and fruit scab.		
'Red Jade'	**late August to mid-November** Red fruits, white flowers, spreading weeper form.	**10-12**
Positives: Graceful spreading growth habit adds winter interest; attractive oblong fruits; yearly prolific red flower buds open to large white blossoms. **Negatives:** Persistent fruit may create an unsightly rotten blob effect until dropping; scab on fruit can dull appearance. **Diseases:** Minor leaf and fruit scab.		
'Red Jewel'	**early September to mid-April** Cherry-red fruits, white flowers, upright open form.	**12-15**
Positives: Phenomenal firm fruits are outstanding and appealing well into spring; very attractive snow white blooms arise from red-pink buds; enticing green glossy leaves. **Negatives:** Mediocre late winter to early spring appearance; very slow-growing tree; tenacious mummies; tree form a bit awkward. **Diseases:** Trace of scab; occasional fireblight.		
'Red Splendor'	**late May to early November** Red fruits, rose-pink flowers, upright spreading form.	**18-20**
Positives: Exceptional profuse, red fruits age to orange-salmon color by mid-fall; red-tinged new, emerging foliage; reliable fruit display and lovely pink flowers. **Negatives:** Severe Japanese beetle feeding; early defoliation due to scab; poor winter ratings due to rotted, half-eaten mummies. **Diseases:** Major leaf and fruit scab.		
'Red Swan'	**mid-September to mid-December** Red fruits, white-pink flowers, true weeper form.	**8-10**
Positives: Tiny red fruits age to orange-red by mid-fall; great contrast of fruits and brilliant yellow fall foliage; fine texture to twigs and leaves; excellent weeping form with upswept branch ends. **Negatives:** Slow to establish. **Diseases:** Trace of scab.		
'Robinson'	**mid-July to late-September** Maroon-red fruits, rose-purple flowers, mounded spreading form.	**22-25**
Positives: Excellent peach to burnt orange fall foliage colors; red-tinged new, emerging foliage maturing to bronze green; reliable lovely flower and fruit displays. **Negatives:** Poor winter ratings due to retention of rotted fruits; tree form is coarse; extensive yearly defoliation from scab. **Diseases:** Major leaf and fruit scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Royal Fountain'	**late July to mid-September** Maroon-red fruits, rose-pink flowers, true weeper form.	**8-10**
Positives: Exceptional long fine weeping branches; petite maroon-red fruits artfully scattered along branches; tree form is greatest asset; fine foliage a bronze-green with burgundy overtones. **Negatives:** Unreliable fruit/flower displays; some defoliation due to scab. **Diseases:** Minor scab.		
'Royal Scepter'	**early August to late October** Cherry-red fruits, rose-pink double flowers, upright spreading form.	**15-18**
Positives: Red fruits age to red-orange; leaves a bronze green with burgundy overtones. **Negatives:** fruits blacken with scab and also as they become overripe; early defoliation due to scab; poor winter ratings due to charcoal-like mummies. **Diseases:** Major leaf and fruit scab.		
'Royalty'	**fruits ineffective** Dark red fruits, red-purple flowers, mounded spreading form.	**12-15**
Positives: Unique red-purple foliage. **Negatives:** Extensive yearly defoliation due to scab; poor winter ratings due to horrific, blackened persistent mummies. **Diseases:** Major leaf and fruit scab.		
'Ruby Luster'	**mid-August to mid- October** Rose-red fruits, rose-pink flowers, broadly rounded form.	**25-28**
Positives: Silvery bark color; unique bronze red-purple foliage. **Negatives:** Extensive yearly defoliation due to scab; very large fruit has russetted, coarse, dull finish and color; large, fast-growing tree. **Diseases:** Major leaf and fruit scab.		
M. sargentii	**mid-August to late October** Dark red fruits, white flowers, low spreading form.	**6-8**
Positives: Greatest asset is attractive low-spreading growth habit; petite snowy white blossoms; effective firm fruits in late summer to early fall. **Negatives:** Fruits deteriorate rapidly; shriveled raisin mummies persist into winter; some winter damage noted. **Diseases:** No scab.		
'Selkirk'	**late July to mid-September** Cherry-red fruits, rose-red flowers, broadly rounded form.	**18-20**
Positives: Excellent floral show as rosy buds open to large rose-red flowers; glossy red fruits; unique red-tinged emerging foliage contrasts nicely with the flowers; foliage changes from burgundy green maturing to a green-bronze; striking profuse red fruits in mid-summer. **Negatives:** Extensive early defoliation due to scab; codling moth damage deforms the large fruit; large fruit creates rotten mess when dropping. **Diseases:** Major leaf and fruit scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Sentinel'	**early September to early February** Red fruits, white flowers, upright spreading form.	**15-18**
Positives: Vase-shaped growth habit; sensational floral display of profuse rose-colored buds open to pink-tinged white flowers; pleasing yellow fall foliage contrasts fruits; attractive firm fruits persist into early spring. **Negatives:** Tenacious fruit mummies may hang into summer; mediocre overall summer appearance. **Diseases:** Minor leaf and fruit scab.		
'Silver Drift'	**mid-September to early April** Cherry-red fruits, white flowers, broadly rounded form.	**18-20**
Positives: Outstanding, persistent, showy glossy red fruit; yearly performance of red buds opening to white flowers is wonderful; interesting contrast of last year's fruit with emergence of new leaves in spring; fast-growing tree; unvarying tree form; retains leaves even though affected by scab. **Negatives:** Tenacious mummies; fruit obscured by foliage. **Diseases:** Minor scab.		
'Silver Moon'	**early September to mid-December** Red-purple fruits, white flowers, mounded spreading form.	**18-20**
Positives: Glossy unique colored fruits; peculiar dense upright candelabra growth habit; good late, snowy white floral show from light pink buds; intense reds and peach fall leaf colors. **Negatives:** Yearly bloom alternates from profuse to sparse; poor winter ratings due to somewhat cluttered growth. **Diseases:** No scab; fireblight can be severe.		
'Sinai Fire'	**mid-September to late November** Red-orange fruits, white flowers, open spreading form.	**12-15**
Positives: Uncommon open growth habit with horizontal branches; good specimen plant; yearly floral show with large blooms. **Negatives:** Fruit scattered and sparse; slow growing; unique form is not for every landscape. **Diseases:** No scab; fireblight can be a problem.		
'Snowdrift'	**mid-August to late November** Salmon-red fruits, white flowers, broadly rounded form.	**18-20**
Positives: Reliable, excellent yearly flower show; distinctly colored attractive fruits; feathery and colorful effect of pedicels in winter. **Negatives:** Fruits shrivel by late fall; chlorotic summer foliage. **Diseases:** Major scab.		
'Spring Snow'	**fruits not produced** No fruit produced, white flowers, broadly rounded form.	**22-25**
Positives: Red-pink buds open to large white flowers; fast-growing tree. **Negatives:** Sterile flowers do not produce fruit; extensive early defoliation due to scab; very large tree. **Diseases:** Major scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Strawberry Parfait'	**mid-August to mid-April** Red-cream fruits, pink flowers, open spreading form.	**15-18**
Positives: Fruits age to deep red; yearly pink flowers borne on spur-lined branches; newly emerged foliage is a burgundy color; leaves mature to green with burgundy tint; unusual, somewhat erratic, upright-spreading growth habit; good fall color; fruits remain firm through late winter. **Negatives:** Tenacious fruit mummies; unusual shape is not for every landscape. **Diseases:** Trace of scab.		
'Sugar Tyme'	**late September to early April** Cherry-red fruits, white flowers, mounded spreading form.	**15-18**
Positives: Stunning sugar-white floral display from pale pink buds; showy, persistent firm fruits through late winter; good overall form; dense foliage. **Negatives:** Mediocre appearance during summer before fruit colors; foliage appears off-color or chlorotic during mid to late summer; fruit drops all at once before bloom. **Diseases:** Trace of scab.		
'Thunderchild'	**fruits ineffective** Blue-purple fruits, rose-red flowers, oval upright form.	**12-15**
Positives: Leaves and new twig growth an intriguing dark purple-red. **Negatives:** Awkward growth; fruiting spur pronounced, long and pointed; extreme lack of flower/fruit/foliage contrasts; extensive early defoliation sue to scab. **Diseases:** Major leaf and fruit scab.		
***M. sargentii* 'Tina'**	**early August to late November** Red-purple fruits, white flowers, low spreading form.	**4-5**
Positives: Petite, densely packed, creamy white flowers arise from diminutive red buds; neat miniature tree or bonsai-like appearance; very dainty aspect to twigs and foliage. **Negatives:** Very slow grower; annual pruning is critical aspect of maintenance. **Diseases:** No scab.		
M. tschonoskii	**fruits ineffective** Yellow-green fruits, white flowers, pyramidal form.	**30-35**
Positives: Large silver-gray leaves; incredible fall foliage colors of purple, orange-scarlet, yellow, and crimson; unique, rare tree form. **Negatives:** Ugly fruit rarely seen or noticed; flowers scattered and sparse; extremely sensitive and susceptible to fireblight. **Diseases:** No scab; extreme fireblight problems.		
'Velvet Pillar'	**late October to mid-November** Maroon-red fruits, pink flowers, upright spreading form.	**18-20**
Positives: Interesting bronze-purple foliage; fruits effective only when the foliage falls off. **Negatives:** Dingy overall appearance to foliage; extensive early defoliation due to scab; scattered and sparse fruit/flower displays; persistent fruit mummies. **Diseases:** Major scab.		

Table 2 (continued). Aesthetic Profiles of Crabapples in Secrest Arboretum.

Crabapple	Time of Effective Fruit Display[1]	Mature Tree Size[2]
'Weeping Candied Apple'	**fruits ineffective (scab)**	**12-15**
	Candied-apple red fruits, rose-pink flowers, open spreading form.	
Positives: Reliable, attractive flowers; interesting horizontal to pendulous branch habit. **Negatives:** Irregular form not for all landscapes; fruit display devastated by scab; extensive early defoliation due to scab; tree form can become awkward. **Diseases:** Major leaf and fruit scab.		
'White Angel'	**mid-October to early February**	**18-20**
	Red fruits, white flowers, broadly rounded form.	
Positives: Reliable, attractive flowers; showy medium-sized abundant fruits; red coloration of most recent twig growth; one of the nicer crabapples as a mature tree. **Negatives:** Awkward splayed shape when young until limbs can withstand fruit load; tenacious mummies distract during mid- to early spring. **Diseases:** No scab.		
'White Cascade'	**mid-September to mid-November**	**12-15**
	Yellow-green fruits, white flowers, true weeper form.	
Positives: Exquisite flower display of cascading flower-covered branches; appealing overall tree form. **Negatives:** Perpetually dingy foliage throughout summer from scab; fruit scab completely destroys any potential fruit effect; early and extreme defoliation. **Diseases:** Major scab on leaves and fruit.		
'Winter Gold'	**early November to mid-January**	**22-25**
	Lemon-gold fruits, white flowers, upright open form.	
Positives: Lemon-green fruits mature to an impressive lemon-gold; nice contrast of bright red pedicels against fruit clusters. **Negatives:** Leaves hang on for a long time, hiding the fruit; long period of bland green fruit well into mid-fall; tree form can be awkward, gangly; extensive fruit scab can diminish impact. **Diseases:** Major leaf and fruit scab; susceptible to fireblight.		

[1] Time of Effective Fruit Display derived from observations conducted monthly throughout the year. Effective fruit impact is defined as the period from when the tree's fruit first contributes to tree aesthetics until the fruit is no longer ornamental.
[2] Tree height is expressed in feet (12 inches = 1 foot).

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Key Results of the 2001 Ohio Green Industry Survey

Gary Y. Gao, John J. Smith, James A. Chatfield, Joseph F. Boggs, Erik A. Draper, and Hannah Mathers

A sales survey entitled *2001 Ohio Green Industry Survey* was conducted from December 2001 to May 2002 as one documentation of the economic importance of the nursery and landscape industry in Ohio in 2001. The survey was designed to measure changes in the industry from previous studies conducted by Tim Rhodus and Jim Hoskins in 1988, 1992, and 1996 (Rhodus and Hoskins, 1997). This project was undertaken with the financial support of the Ohio Nursery and Landscape Association (ONLA). The list of licensed nursery dealers and nursery producers was provided by the Ohio Department of Agriculture (ODA).

Based on our survey results, the estimated value of overall sales by certified nursery stock dealers and producers in Ohio was $2.79 billion for 2001 (Table 1). The annual growth rate was 8.5% between 1996 and 2001. Of this total, approximately $2.19 billion was from licensed nursery dealers and $599.4 million from licensed nursery producers. As indicated, this survey is a significant underestimate of the overall green industry in Ohio since it measures only licensed nursery dealers and producers.

During 2001, the sales in Landscape Services in Ohio totaled $1.16 billion (combined total for Landscape Construction/ Installation and Landscape Maintenance), which was $209.6 million more than the figure of $945.6 million in 1996. This figure represents a total increase of 22.2% during the last five years, or an annual growth rate of 4.4%.

Retail Garden Center sales totaled $534.9 million, and Wholesale sales totaled $834.2 million, more than twice the figure of $316.0 million in 1996. Sales for the category Other totaled $263.2 million, more than twice the figure of $129.8 million in 1996.

Note: This survey is a significant underestimate of the total green industry in Ohio since it measures only the licensed nursery stock dealers and producers. Businesses such as sod producers, arborists, grounds management companies and divisions, lawn-care companies, etc., are not included in the survey relative to their revenues and numbers of employees in Ohio. In addition, due to survey methodology, large discount chain stores are under-represented in survey responses, thus further underestimating the size of the green industry in Ohio.

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The total number of employees in the nursery industry was estimated at 96,576 for 2001 (Table 2). This was up approximately 6.6% from 1996 at an annual rate of 1.3%. The number of full-time employees was 32,670. The number of part-time employees was 19,124, while the seasonal employees number was estimated at 44,782.

Overall, the number of positions in the nursery and landscape industry is at an all-time high of 96,576.

The statewide estimate of the 2001 payroll for the nursery and landscape industry was $882.9 million. This figure represents an increase over 1996 of 33.8% or an annual

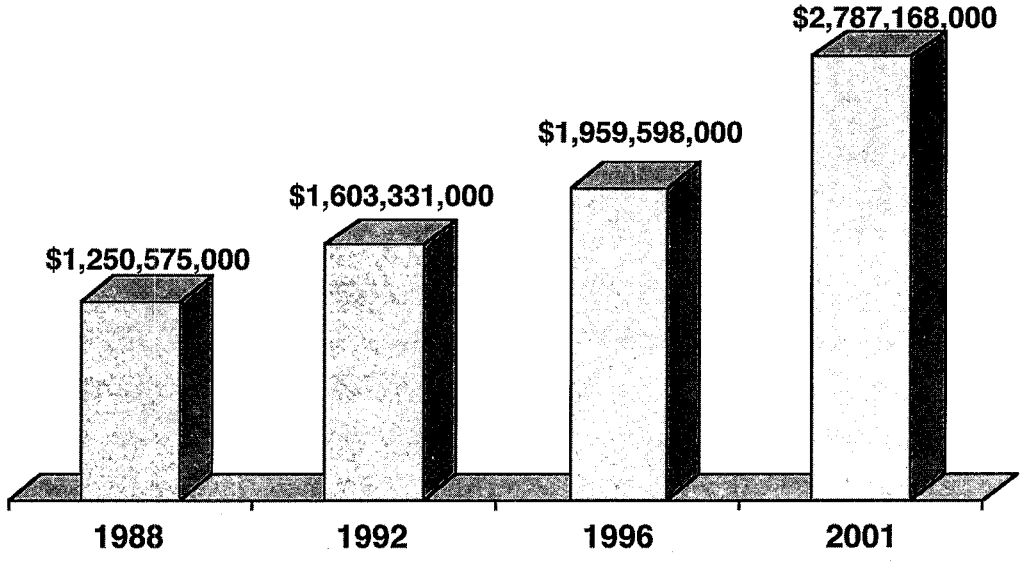

Table 1. Estimated value of overall sales by certified nursery stock dealers and producers in Ohio for 2001.

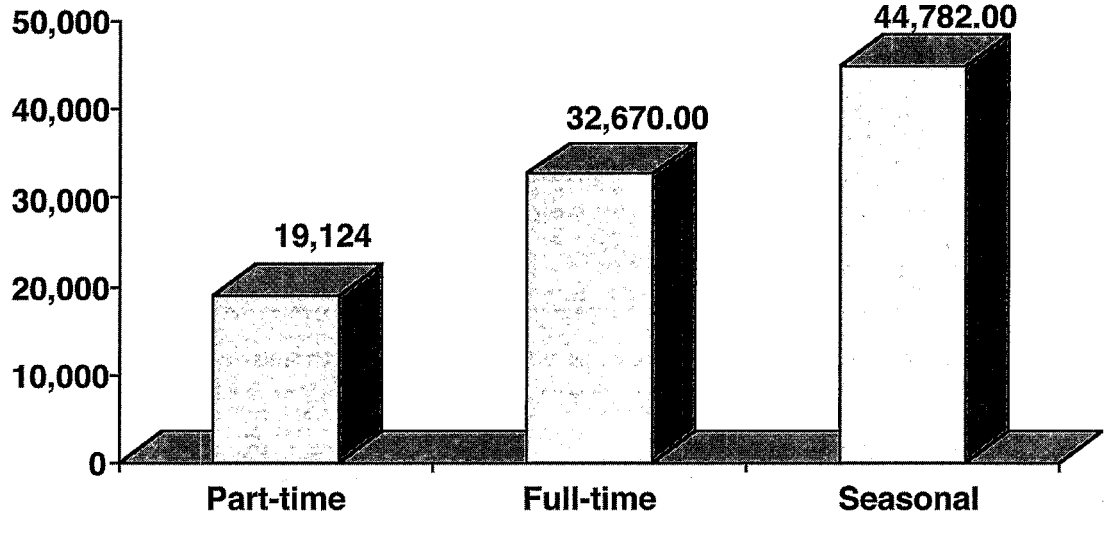

Table 2. Total number of employees in the nursery industry was estimated at 96,576 for 2001.

growth rate of 6.8%. The nursery and landscape industry contributed an estimated $274.9 million in taxes (property, sales, FICA, and income) in 2001, an increase of 40.2% from 1996 (Table 3).

Ohio Nursery and Landscape Industry

Between 1996 and 2001, the industry grew 42.3%.

The Ohio Nursery and Landscape Industry represents 5,088 licensed nursery stock dealers and 1,541 nursery stock producers. These businesses are commonly recognized as: Wholesale Producers, Landscape Installation and Construction, Landscape Maintenance, Retail Garden Centers, and Mail Order firms. Their products and services enhance the beauty and value of Ohio's environment.

Sales revenue for 2001 was approximately $2.79 billion.

The Ohio Nursery and Landscape Industry Is Many Businesses Working Together

Growers, retailers, and landscaping firms make up the industry.

The largest segment of the Ohio industry was Wholesale Production and Distribution at $834.0 million. Landscape Construction and Installation ranked second at $752.1 million. Retail Garden Center sales ranked third at $534.8 million. Landscape Maintenance activity ranked fourth at $403.1 million. Revenues generated from other activities such as snow plowing and retailing other products generated an additional $263.2 million for nursery stock producers and dealers.

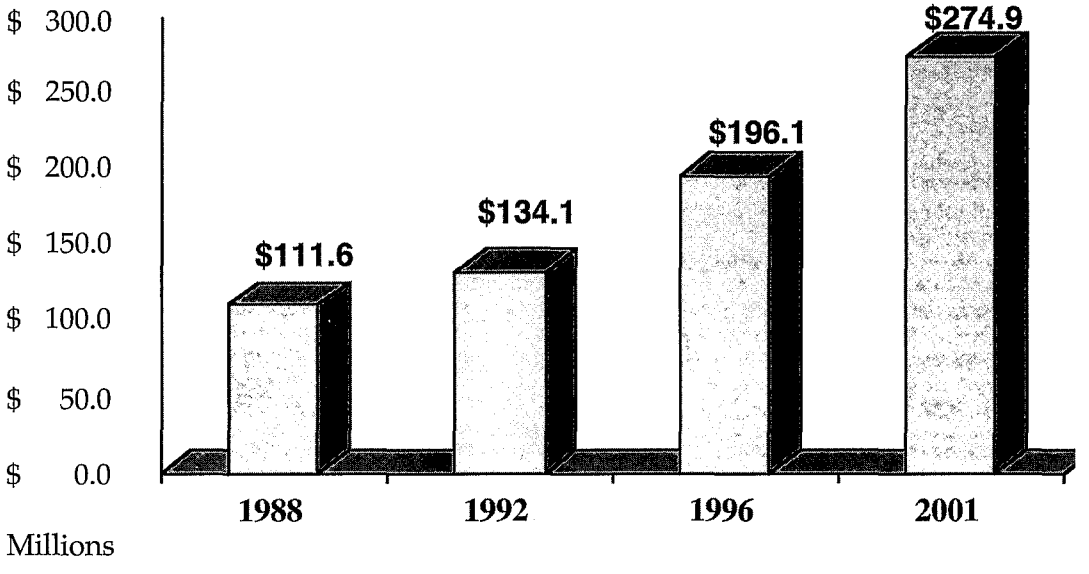

Figure 3. The nursery and landscape industry paid an estimated $274.9 million in taxes (property, sales, FICA, and income) in 2001, an increase of 40.2% from 1996.

The Ohio Green Goods Industry Is Providing Employment Opportunities

More than 96,000 Ohio workers are employed in this industry.

The total number of employees in the nursery industry is estimated at 96,576 (Table 2). While many of the jobs in the industry are seasonal in nature, the combined number of full-time and part-time positions was approximately 51,794. The total payroll of the industry for 2001 was $882.9 million.

Between 1996 and 2001, overall industry payroll increased by $223.2 million and overall industry employment increased by 5,940 positions.

The Ohio Nursery and Landscape Industry Is Contributing to Ohio's Economy

Between 1996 and 2001, overall tax payments grew 40.2%

Total taxes paid in 2001 were 40.2% higher than comparable figures for 1996, 105.0% higher than 1992 payments, and 146.3% higher than 1988 payments. In 2001, the industry paid an estimated $13.9 million in property taxes, $68.9 million in sales taxes, $100.0 million in employee taxes, and $92.1 million in income taxes, for a total of $274.9 million.

Benchmarking One Segment of the Ohio Nursery and Landscape Industry

For perspective, the Landscape Services component of the Ohio green industry survey was compared with other types of Ohio industries (Table 4).

Landscape Services in Ohio totaled approximately $1.16 billion in 2001.

The combined value of Landscape Installation/Construction and Landscape Maintenance services in Ohio was $1.16 billion. Comparing this to other service industries in Ohio indicates that this is a growing and healthy industry.

Using the most recently available information from the United States Commerce Department, landscape services in Ohio

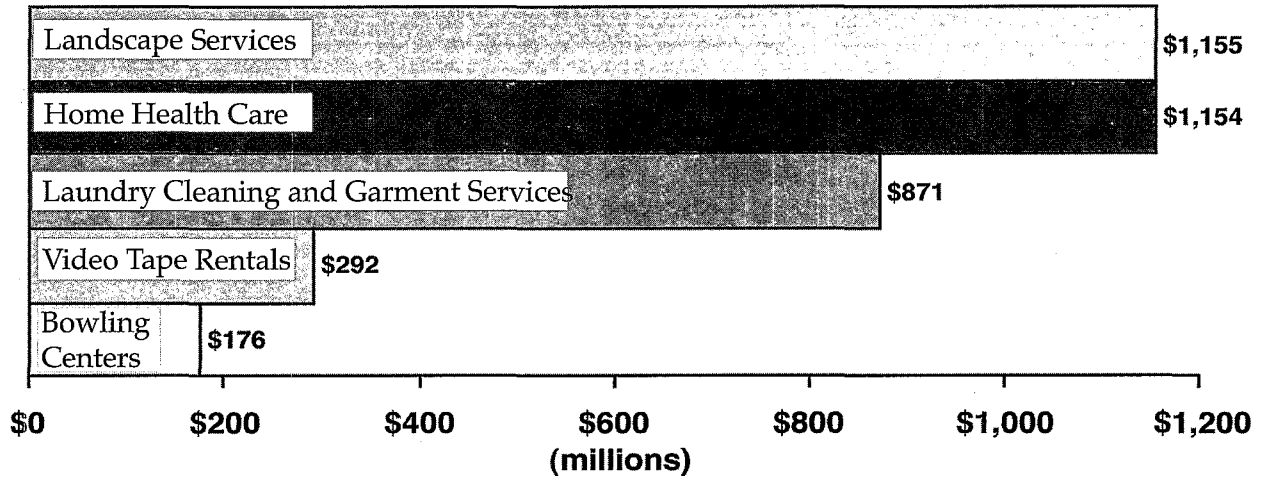

Table 4. Landscape services in Ohio generated more sales revenue than other types of Ohio industries. These included Home Health Care, Laundry Cleaning and Garment Services, Video Tape Rentals, and Bowling Centers.

generated more sales revenue than Bowling Centers, Video Tape Rental, Laundry Cleaning and Garment Services, and Home Health Care.

(Source: 1997 Economic Census: Comparative Statistics for Ohio: 1987 SIC Basis: Service Industries.)

Survey Background

It should be noted that this survey is just one small snapshot of the green industry in Ohio. It does not truly measure most of the green service industry *(e.g.,* plant health care and maintenance companies, arborists, etc.). It does not measure most of the greenhouse production and lawncare industry. It does not adequately measure discount chain stores.

And it does not attempt to measure overall economic impact of the green industry. In fact, the Ohio Department of Agriculture estimates that the nursery, landscape, floriculture and turfgrass production and processing of plant product output in Ohio (which includes economic impact) was $24.6 billion in 2001 and is the largest segment of agricultural economic activity in Ohio, comprising 37% of the total.

Financial support for this study was provided by the Ohio Nursery and Landscape Association.

This survey was conducted by Dr. Gary Gao, John Smith, and Jim Chatfield, Ohio State University University Extension.

For additional information, contact: Dr. Gary Gao, 513-732-7070, or Jim Chatfield, 330-263-3831, or Bill Stalter, Executive Director, Ohio Nursery and Landscape Association, 614-899-1195 or toll-free at 1-800-825-5062. **http://www.onla.org**

For full details on survey methodology, response rates, and additional data collected, contact one of the individuals previously listed.

Key survey results can also found on **http://www.onla.org**

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We are grateful for funding for this survey, provided by the Ohio Nursery and Landscape Association.

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The USDA/Agricultural Research Service Research Weather Network in Lake County, Ohio — 2002 Update

R. D. Brazee, R. C. Derksen, C. R. Krause, K. A. Williams, D. Lohnes, M. G. Klein, M. Reding, R. Lyons, W. Hendricks, R. Zondag, R. D. Fox, and D. Herms

Introduction

Weather is among the key factors to be dealt with in managing nursery field operations. In recognition of this and as part of a cooperative field research program, the Application Technology Research Unit of USDA/Agricultural Research Service; nursery growers in Lake County, Ohio; and cooperating staff of The Ohio State University's Ohio Agricultural Research and Development Center began development of a research weather network in 2000.

Initial efforts involved implementation of a portable weather station as part of a multi-year, field research project designed to compare efficacy of conventional axial-fan (airblast) and air-curtain spray application systems in control of scab disease in crabapple.

Permanent meteorological stations have been installed in northeastern Ohio production nurseries to archive weather data during horticultural experiments. Insect and disease management research require detailed knowledge of weather conditions. Data such as soil moisture and temperature, air temperature, relative humidity, precipitation, wind speed, wind direction, barometric pressure and leaf surface moisture that directly impact disease and insect development are being recorded.

Unique to this cooperative project is that this research data is also available to growers as displayed on the USDA, ARS, ATRU website and the NRCS weather network. Impacted by the USDA, ARS, ATRU weather station network are studies on soil insects, sprayer efficacy on apple scab disease, nursery crop phenology, and plant conditioning.

The Weather Stations

Development of the permanent components of the weather network was begun in 2001 with installation of a station at Sunleaf Nurs-

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ery, Madison, Ohio. Construction of a second station was undertaken in 2002 at Klyn Nursery near Perry, Ohio.

These locations were selected as representative of commercial nursery locations, and of known or expected differences due to terrain and distance from nearby Lake Erie. Space for each station was donated by the host nursery as a contribution to the industry and to cooperative research programs.

The central component of each station is a 10-meter (33-ft.) tilt-down instrument tower set on a concrete base and equipped with a lightning-protection system. The Madison (Sunleaf) tower is shown in Figure 1. There are underground AC power and telephone data transmission lines serving each tower.

The towers and instrumentation employed are basically adapted UT-30 systems as available from Campbell Scientific, Inc. (Logan, Utah). Instrumentation is deployed in accordance with National Oceanic and Atmospheric Administration (NOAA) standards. Data as currently available are accessible at a web site discussed later.

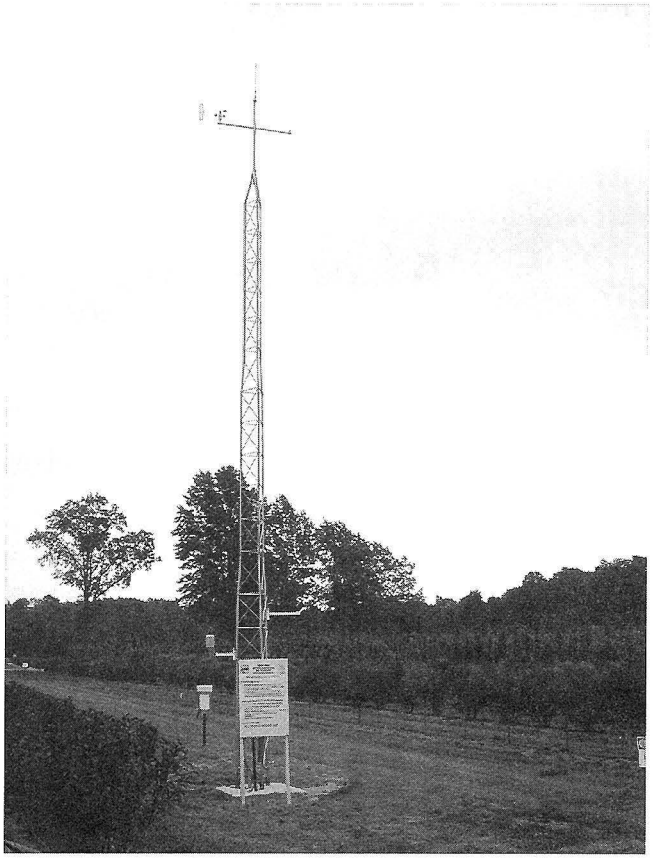

Figure 1. The weather station at Sunleaf Nursery, Madison, Ohio. The station near Perry, Ohio, at Klyn Nursery is similar. The shielded temperature and humidity sensor can be seen on the support arm at the left side of the tower, with the solar pyranometer appearing on the support arm opposite, at the right. The rain-snow gauge is in the near background just beyond the tower.

Weather Instrumentation

Wind Speed and Direction

Wind speed and direction data are provided by a windset combination of a cup anemometer and vane electronic sensors mounted at the standard 33-ft. level of the tower. This deployment is at a higher elevation than typical of some agricultural meteorology applications to assure adequate clearance above hoop-houses or treetops typical of nursery field operations.

On the web site, wind speeds are given in miles per hour and wind direction as azimuthal degrees (zero to 360) clockwise from zero (north).

Air Temperature and Relative Humidity

Air temperature and relative humidity data are provided by a thermister and Vaisala relative humidity sensor combination mounted at about the 2-meter level. The sensors are enclosed in a cylindrical, vented shield for protection from rainfall, foreign matter, and solar heating.

Air temperature and relative humidity are expressed in Fahrenheit degrees and percent, respectively.

Solar Radiation

Solar radiation is monitored with a pyranometer sensor mounted on the south-facing side of the tower opposite the temperature and humidity sensors.

Solar radiation is expressed in watts per square meter.

Atmospheric Pressure

Atmospheric pressure data are provided by an electronic barometric pressure sensor located in the instrumentation enclosure that houses the data logging system. One important application of barometric data will be to enable accurate determinations of local atmospheric moisture and latent-heat conditions for prediction of overnight low temperatures. Barometric data are not currently available on the web site.

Soil Temperature

Initially, soil temperature data will be acquired by means of sensors placed at 2-, 4-, and 8-inch depths in soil adjacent to the tower. Eventually, soil temperature and soil moisture will be monitored at these and additional depths. These data are not currently available on the web site.

Rain and Snow

Rain and snow are monitored with an electronic "tipping-bucket" unit. In winter months, a heating system is provided to enable snowfall measurement on an inches-of-liquid-water basis.

Data Logging System and Data Access

A Campbell Scientific CR23X data logging system is used to digitally acquire and store data from the deployed sensors. The system is housed in a tower-mounted enclosure providing backup battery power in event of AC-line power failure.

Data can be secured for post-processing and archiving by computers at local or remote sites equipped with software and a modem enabling communication with the system. Some data are currently available on a web site that is under development, and accessible at:

www.oardc.ohio-state.edu/usdaweather/

The Madison (Sunleaf) or the Perry (Klyn) station can be selected from among the listed offerings at the site. These are currently the only two sites on the USDA network.

The remaining listings in the web site are in the Ohio State University weather network at various additional locations in the state.

Discussion

Research and nursery-industry uses for data from this weather network envisioned at this time are:

- Archival records of conditions during completed spraying or other grower operations.
- Records of weather conditions during past growing seasons.
- Water management and irrigation scheduling.
- Prediction of overnight low-temperatures with potential for crop damage.
- Forecasting of insect or disease onset, dormancy entry or emergence, based on degree-day calculations and research data.
- Disease-control spray applications based on weather-triggered alerts.
- Research on seasonal or other gradations in weather conditions near Lake Erie.

Acknowledgments

The authors are grateful for assistance, recommendations, or suggestions in establishing the weather network as provided by A. Doklovic, L. Horst, B. Nudd, D. Troyer, M. Sciarini, T. Demaline, E. Losely, K. Losely, J. Bonta, S. Lowe, R. Bergolc, L. Melenbacker, D. Baumgartner, G. Powell, and for others at Sunleaf and Klyn nurseries who helped in many ways. Special thanks go to C. Knox of Campbell Scientific who has helped solve some problems along the way.

~ 21 ~
The OSU Chadwick Arboretum Learning Gardens

Dr. Steven Still and Annette Duetz

The Chadwick Arboretum Learning Gardens are an outdoor laboratory for learning about constructed landscapes appropriate to the urban Midwest. Students, faculty, and staff participate in the design, installation, and maintenance of the gardens. The landscape and nursery industries also participate in design ideas, plant selection, and construction. The general public can also become involved as passive visitors, active learners, or volunteers alongside our students.

As a part of the Chadwick Arboretum, the Learning Gardens are located on the grounds surrounding Howlett Hall, which houses the Department of Horticulture and Crop Science. Within the gardens, various themes are featured using perennials, annuals, shrubs, and small trees. The Annual Cultivar and Pansy Trials are also featured in the Learning Gardens.

In the summer of 2001, Chadwick Arboretum staff began working on the preliminary plans for the Learning Garden with conceptual help from Urban Environments, a Columbus landscape and design firm. In fall 2002, installation of irrigation, hardscapes, and lighting was underway. A major portion of the garden will be installed in spring 2003.

Dr. Steven Still, Annette Duetz, Department of Horticulture and Crop Science, The Ohio State University.

The van Fossen Wildflower Garden

The Chadwick Arboretum staff installed the van Fossen Wildflower Garden just west of Howlett Hall in the spring of 2002. This garden emphasizes woody and herbaceous plants native to the United States. The design was conceived by students in Professor Martin Quigley's design class and was refined by Professor Quigley.

The garden takes advantage of the shady location and introduces rocks and stones for textural contrast. Along the pathway, which has been installed by students of Dr. Pablo Jourdan, two benches have been placed for relaxation and contemplation. Soil amendment (Professional Mix) and mulch (Gardener's Mulch) were supplied by *Kurtz Brothers*.

The Kleinmaier Perennial Garden

For the second major garden, the Chadwick Arboretum called on garden designer and Ohio State horticulture graduate Deb Knapke to design the new Kleinmaier Perennial Garden. Knapke presented the greatly enhanced design, and installation will begin in spring 2003 after hardscapes, irrigation, and new light fixtures are installed this fall.

The Kleinmaier Perennial Garden design consists of three beds and covers some 6,000 square feet. It will be located north of Howlett Hall and west of Kottman Hall, surrounding the Gazebo.

"My goal was to use as many perennials as possible for teaching purposes," Knapke said.

Shade Bed, West of Howlett Hall's Main Entrance

This fall the Learning Gardens began developing a third bed in front of Howlett Hall. This bed had been the design project in one of Dr. Steve Still's design classes.

With the help of our students and *Kurtz Brothers,* we were able to install many interesting and some rare shade plants. A mulch walkway winds through the bed, and a bench invites rest.

Annual Displays Throughout the Year

In addition to the previously mentioned theme gardens, there are many annuals displayed in pots as well as in the beds of the Learning Gardens. The emphasis this past summer was on tropical plants — some noted for their bold foliage and others for their intense flower colors.

Six different shade and sun pots, as well as two beds, featured the unusual plants, and various combinations were displayed. For example, dark purple Elephant Ear, *Calocasia escutenta* 'Jet Black Wonder;' Neranjilla, *Solanum qutitoense;* Angelonia, *Angelonia angustifolia,* as well as many different and interesting kinds of Coleus and ornamental sweet potato vines were featured.

For the winter display, many different cultivars of pansy and violas were combined with kale, cabbage, *Acorus gramineus,* and parsley. Some of the evergreen centerpieces in the pots include unusual conifers such as *Pinus densiflora* 'Oculus Draconis' and *Chamaecyparis obtusa* 'Coralliformis.'

The smaller pots featured *Chamaecyparis* 'Gold Mops,' *Taxus* x 'Bean Pole,' and *Pinus strobus* 'Umbraculifera' to name a few.

Mayhew Scholarship

The Chadwick Arboretum is very fortunate to offer opportunities for 10 horticulture students to develop horticultural skills through the Mayhew Scholarship program. Undergraduate students, who excel in academics, show leadership potential, and have an interest in woody plants and perennials, are given opportunities to work with faculty and Chadwick Arboretum staff in the garden year round. Tuition, fees, and a work stipend are provided by the program.

~ 22 ~
Choosing Soil Testing Labs

Gary Y. Gao, Maurice E. Watson, Joseph F. Boggs, and James A. Chatfield

"Don't guess — soil test!" has long been a recommendation for farmers and growers, and it remains true for modern horticulture, from nursery and greenhouse growers to landscapers and arborists. A soil test is an excellent way to measure soil fertility. It is also a very inexpensive way to help maintain good plant health and maximum crop productivity.

The standard soil test provides the status of phosphorous (P), potassium (K), calcium (Ca), magnesium (Mg), pH, cation exchange capacity (CEC), lime requirement index, and base saturation. Additional tests are also available for iron (Fe), zinc (Zn), manganese (Mn), soluble salts, and nitrates.

The Research and Extension Analytical Laboratory (REAL Lab) run by The Ohio State University was closed in December 1998. However, there are several commercial labs that offer the same or similar tests as were used by the REAL Lab. There are also soil and tissue testing labs administered by land-grant universities such as Michigan State University, Penn State University, and the University of Kentucky. For a fee, most of these labs will test soil, soilless media, plant tissue, compost, and water. The amount of fertilizers, timing of fertilization, and amount of soil pH modifying agents, such as lime, will be given according to the type of crop, based on soil test results.

Gary Y. Gao, Ohio State University Extension, Clermont County; Maurice E. Watson, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster, Ohio; Joseph F. Boggs, Ohio State University Extension, Hamilton County and Southwest District; and James A. Chatfield, Ohio State University Extension, Northeast District and Department of Horticulture and Crop Science.

How Do You Choose a Soil Testing Lab?

Growers should consider several factors in choosing a soil-testing laboratory. This article refers to laboratories that determine concentrations of plant-available nutrients in the soil. Soil-testing laboratories are generally not regulated by state or federal agencies. Consequently, it is important for growers to investigate these laboratories by obtaining information about their performance, operation, and service before sending soil samples for analysis. A grower requires assurance that the test results will be of high quality, be credible, and meaningful. Specific guidelines are discussed here to aid the grower in evaluating a soil-testing laboratory.

Factors to Consider

Test Methods

The use of appropriate test methods is very important in order to accurately determine the concentrations of plant-available nutri-

ents in the soil. Decades of research at many land-grant universities have resulted in soil-testing methods that are specific for soils in particular regions of the United States.

For example, methods developed for testing the predominant soils in the Southern region of the United States may not be applicable for soils in the North Central region. The North Central Regional Research Committee (NCR-13) has developed methods that work best on soils in the North Central region.

A publication of these methods is entitled *Recommended Chemical Soil Test Procedures for the North Central Region* (1). Laboratories that test Ohio soils should use these procedures. Therefore, potential clients need to determine if these testing methods, recognized for Ohio soils, are being used by the laboratory.

Laboratory Proficiency

The proficiency of a laboratory refers to its ability to produce accurate and precise test results. It is difficult for a laboratory to independently assess this factor. Thus, regional soil-testing research committees and other organizations established the North American Proficiency Testing (NAPT) program in 1998. This program is backed by a professional scientific organization, the Soil Science Society of America.

A main purpose of the NAPT is to provide "double-blind" check samples to laboratories that wish to monitor and improve the quality of their soil-testing data. NAPT not only provides the check samples but also collects and statistically analyzes the data from laboratories in the program. Participating laboratories receive a summary of their performance for each soil-test method.

Continued self-evaluation and adjustment improves the integrity of the soil-test results. A prospective client should ask the laboratory management if they are members of the NAPT program.

Laboratory's NAPT Results

It is important that a representative of the laboratory review with the potential client the lab's NAPT quarterly test results and compare results with those summarized for all NAPT participating laboratories. Information for each test parameter of interest to the client should be included. Growers should ask for this comparison in order to make an informed decision about a laboratory.

Other Customers

The potential client should ask the laboratory to provide the names and telephone numbers of 10 customers. This allows growers to evaluate the laboratory from the perspective of users like themselves.

Units of Results

Ask a laboratory representative what units are used for each test parameter. Some laboratories use lbs/a (pounds per acre), ppm (parts per million), or lbs/1,000 square feet. If results from different labs are compared, make sure the units associated with the results are the same.

For a valid comparison, a simple conversion may be necessary. For example, to convert ppm to lbs/a, multiply the ppm value by 2. Certain test parameters may have unfamiliar units, such as meq/100 g for cation exchange capacity. Ask the laboratory representative to explain the meaning of the units if they are unclear.

Categories of Quantity

Some laboratories may place test results into categories. Examples are the categories of low, medium, and high. These categories usually denote a range of test values. It is likely that the categories given by one laboratory will not represent the same nutrient concentrations for another laboratory. Ask

the laboratory to define each range that is used. In addition, find out if the categories are crop-dependent or if categories are calibrated for specific soil conditions (*e.g.*, soil types).

Lime and Fertilizer Recommendations

Determine if the soil-testing laboratory provides recommendations for the application of lime and fertilizer for the crops of interest. The *Tri-State Lime and Fertilizer Recommendations* provide guidelines for corn, soybeans, alfalfa, and wheat that will be grown in Ohio soils (2).

In addition, lime and fertilizer recommendations for these crops and other agronomic crops are available through the Ohio State University's *Ohioline* Internet service. The web address to access Ohioline is: **ohioline.osu.edu**

The *Ohio Vegetable Production Guide* lists fertilizer recommendations for vegetable crops (3). The basis for these recommendations is the university research that has been conducted for the soils and growing conditions of Ohio. Ask the laboratory representative if these recommendations are used.

Also ask about the basis for lime and fertilizer recommendations that are used for other crops. Are they calibrated for your specific soil types or growing conditions? Ask if crop rotations and yield goals are considered. In addition, ask if the timing of the application of lime and fertilizer is included in the laboratory's recommendations.

Turn-Around Time

Ask how long it takes the laboratory to do the routine soil testing and return the results. In order for the results and recommendations to be useful, the turn-around time must be as short as possible. A good laboratory should be able to provide the results in two to three working days for the routine soil tests of pH, lime requirement, phosphorus, potassium, calcium, and magnesium. It is also very important to make sure the laboratory does not sacrifice accuracy by short cutting the methods to attain this turn-around time. It is a good idea to check the turn-around time with those who have used the laboratory.

The Internet can be a useful system to obtain test results rapidly. Find out if the laboratory can provide the results on the Internet. In addition, determine if the recommendations for the application of lime and fertilizer can also be obtained on the Internet.

In some cases, the laboratory may be able to accept the customer's sample identification information over the Internet, rather than using the sample information form. Most laboratories will also have an e-mail address that will allow direct and rapid communication with the laboratory manager and/or laboratory professional.

Visiting the Laboratory

It is important to visit the soil-testing laboratory before submitting samples. A representative of the laboratory should not hesitate to show a potential client the testing area. During the visit, observe the orderliness and cleanliness of the work area. Ask how the samples are handled. In addition, ask how the data is handled and ask about quality control procedures.

Reference Check Samples

Find out if the laboratory routinely uses internal "blind" and "double-blind" check samples where possible. A "blind" check sample is one that the laboratory technician knows is a check sample and is aware of the range of acceptable values for the parameters being tested. The technician uses this kind of check sample to make sure the method and instrument are performing normally. A "double-blind" check sample is one

that the laboratory technician does not know is an internal check sample. In this case, the laboratory manager evaluates the data and determines if the test results produced are within the acceptable range.

Charting Quality Control

The testing laboratory should continuously evaluate its quality by charting its check soil-sample results over time. This allows for measurement and assessment of the variation over time. Warning limits and action limits should then be established to assist in the recognition of unacceptable results if a problem with the test should arise.

Ideally, quality-control charts need to be used for each test parameter. A potential client should ask to review these charts with the laboratory management prior to selecting a laboratory.

Sample Information and Test Result Forms

Ask the laboratory for examples of the information form and the final test result form. Study these forms and ask for an explanation of anything that is unclear. Determine how many samples can be represented on each form. Also, sampling instructions are usually provided on the information form.

Containers that hold the sample are usually provided along with the information form. Ask to see an example of the container.

Test Kits

Most soil-testing laboratories supply test kits for their customers. At a minimum, the test kits should contain the sample information form and soil sample container. Some additional information may be included with the test kit. Find out about the sample kits and how they are obtained from the laboratory.

Production Professionals

Find out if the laboratory has professionals who are trained in agronomy, horticulture, or soil science to work with the customer.

Before deciding on a soil-testing laboratory, visit the laboratory and meet with a professional to discuss concerns about testing soil. When visiting a laboratory, ask to review the educational and training credentials of the professionals.

Laboratory Test Prices

Prices for soil testing often vary greatly from one laboratory to the next. Ask about the prices. Determine if the price for each test or test package is given in writing. Also find out if discounts are given for large numbers of samples and whether prices are negotiable. If you are a member of a grower organization, ask if discounts are provided to organization members.

Other Testing Services

Determine what other services the laboratory offers that are in conjunction with soil testing. Especially, find out if the laboratory offers plant-tissue analysis. This tool can be very useful along with soil testing to monitor the nutrient status of the soil or to isolate problem fertility situations in the field. Find out if the laboratory includes sample collection as an optional service.

Consultation with your local county Extension agent may also be worthwhile in deciding which laboratory to use. In addition, if a crop consultant is used, then the grower should discuss these factors with the consultant in regard to the selection of a soil-testing laboratory.

Additional time and effort in selecting a quality soil-testing laboratory will pay off. Don't just assume the laboratory gives quality test results. Find out for sure.

Refer to the list of the soil and tissue testing labs in Ohio and neighboring states that is included here. The list is provided to you solely as a reference. The inclusion of any lab on this list does not carry The Ohio State University's endorsement nor does exclusion imply any discrimination.

Soil and Tissue Testing Labs

Soil and Plant Nutrient Laboratory
MSU Extension Service
Department of Crop and Soil Sciences
Michigan State University
East Lansing, MI 48824-1325
517-355-0218

Tests soil, soilless media, plant tissue, compost, nutrient solutions, water, limestone and marl partial size analysis, sand classification, phosphorus absorption, isotherms, and performs other special analysis upon request.

Agricultural Analytical Service Laboratory
Penn State University
University Park, PA 16802
814-863-0841

Tests soil, soilless media, plant tissue, manure, compost, sludge, and performs other special analysis upon request.

Soil Testing Laboratory
University of Kentucky
103 Regulatory Service Building
Alumni and Shawneetown Roads
Lexington, KY 40546-0275
606-257-4496

Tests soil, soilless media, plant tissue, compost, nutrient solutions, water, and performs other special analysis upon request.

Alloway Testing
508 Bissman Ct.
Mansfield, OH 44906
419-223-1362 Lima
419-535-1644 Mansfield

Tests soil, manure, sludge, water, and performs other special analysis upon request.

A & L Great Lakes Lab
3505 Conestoga Drive
Fort Wayne, IN 46808
219-483-4759

Tests soil, soilless media, plant tissue, feed, manure, compost, sludge, nutrient solutions, water, environmental pesticides, and performs other special analysis upon request.

Brookside Labs
308 S. Main Street
New Knoxville, OH 45871
419-753-2488

Tests soil, soilless media, plant tissue, feed, manure, compost, sludge, nutrient solutions, water, and performs other special analysis upon request.

CLC Labs
325 Venture Drive
Westerville, OH 43081
614-888-1663

Tests soil, plant tissue, water, and performs other special analysis upon request.

Calmar Lab
130 S. State Street
Westerville, OH 43081
614-523-1005

Tests soil, soilless media, texture test, and plant tissue.

Holmes Lab
3559 U.S. Rt. 62
Millersburg, OH 44654
800-344-1101 or 330-893-2933

Tests soil, feed, manure, micro toxins, and water.

Ream & Haager Laboratory
1226 Kaderly Street
New Philadelphia, OH 44663
330-343-3711

Tests soil, water, and other special analysis upon request.

Spectrum Analytical, Inc.
P. O. Box 639
Washington Courthouse, OH 43160
800-321-1562

Tests soil, soilless media, plant tissue, feed, manure, compost, sludge, nutrient solutions, water, and performs other special analysis upon request.

References

1. Brown, J. R. (Ed.). 1998. *Recommended Chemical Soil Test Procedures for the North Central Region.* North Central Regional Research Publication No. 221. Missouri Agricultural Experiment Station SB 1001. Columbia, Missouri.

2. Vitosh, M. L., J. W. Johnson, and D. B. Mengel (Eds.). 1995. *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa.* Extension Bulletin E-2567. Michigan State University, East Lansing, Michigan.

3. Precheur, R. J. (Ed). 1999. 1999 *Ohio Vegetable Production Guide.* Extension Bulletin 672. The Ohio State University, Columbus, Ohio.

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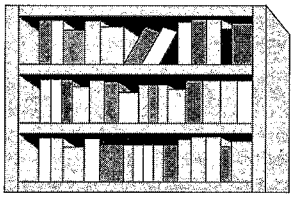
Top Horticultural References for a Green Industry Professional's Library

Gary Y. Gao and Pamela J. Bennett

Good horticultural references are great tools for green industry professionals, horticultural educators, and gardeners. The list presented here is a compilation of references that we, as Extension agents, use on a regular basis.



As you can imagine, this list is a work in progress.

If you know of a book or books that we should include in next year's *Ornamental Plants* research circular, please e-mail Gary Gao at gao.2@osu.edu. Make sure you list the name of the book, the author, the publisher and year, the ISBN number, and a brief review.

There are also numerous Ohio State University Extension bulletins that we use on a daily basis. Many of these useful bulletins have been featured in the weekly *Buckeye Yard and Garden Line* over the years. Please visit *Ohioline* at **ohioline.osu.edu** for OSU Extension publications online. If you would like to order hard copies of these OSU publications, please contact your local Extension office. If you are not a resident of Ohio, you can order OSU Extension publications directly from OSU's Communications and Technology Media Distribution office at 614-292-1607.

Here is our list, giving the name of the book, the author, the publisher and year, the ISBN number, the approximate list price, and a brief review.

We hope that this list will serve as a good starting point for your horticultural library.

Please turn to the following page.

Gary Y. Gao, Ohio State University Extension, Clermont County; and Pamela J. Bennett, Ohio State University Extension, Clark County.

Hortus Third
The Staff at the Liberty Hyde Bailey Hortorium
MacMillan Publishing Company, 1976
ISBN 0-02-5054708
$150
A concise dictionary of plants cultivated in the United States and Canada.

Wyman's Gardening Encyclopedia
Donald Wyman
MacMillan Publishing Company, 1986
ISBN 0-02-632070-3
$55
An excellent gardening reference.

Manual of Herbaceous Ornamental Plants
Steven M. Still
Stipes Publishing Company, 1994
ISBN 0-87563-433-8
$41
The most comprehensive book on herbaceous ornamental plants.

Manual of Woody Landscape Plants: Their Identification, Ornamental Characteristics, Culture, Propagation, and Uses
Michael A. Dirr
Stipes Publishing Company, 1998
ISBN: 0875637957
$57
The most comprehensive book on woody ornamental plants.

Dirr's Hardy Trees and Shrubs: An Illustrated Encyclopedia
Michael A. Dirr
Timber Press, 4th Edition, 1997
ISBN: 0881924040
$69
An excellent book on trees and shrubs with numerous color pictures.

Western Fertilizer Handbook: Second Horticulture Edition
Soil Improvement Committee of the California Fertilizer Association
Prentice Hall, 2nd Edition, 1997
ISBN: 0813431468
$34
A concise and practical book on fertilizers and plant nutrition.

Botany for Gardeners: An Introduction and Guide
Brian Capon
Timber Press, 1990
ISBN 0-88192-258-7
$29
An easily digestible overview of the fundamentals of botanical science as they relate to horticulture; a perfect book for beginners or for a botany review.

Weeds of the Northeast
Richard H. Uva, Joseph C. Neal, and Joseph M. Ditomaso
Cornell University Press, 1997
ISBN: 0801483344
$29
An excellent reference on the biology and identification of weeds.

A New Tree Biology
Alex L. Shigo
Shigo and Trees, Associates, 2nd Edition, 1997
ISBN 0-943563-12-7
$75
Facts, photos, and philosophies on trees and their problems and proper care.

Plant Propagation

Plant Propagation: Principles and Practices
Hudson T. Hartmann, Dale E. Kester, Fred T. Davis Jr., and Robert Geneve
Prentice Hall Career and Technology, 2001
ISBN: 0136792359
$90
A very comprehensive book on plant propagation.

Ball Perennial Manual: Propagation and Production
Jim Nau
Ball Publishing, 1996
ISBN: 1883052106
$64
A comprehensive reference for growers of perennials.

Tree and Shrub Insect and Diseases

Diseases of Trees and Shrubs
Wayne A. Sinclair, Howard H. Lyon, and Warren T. Johnson
Cornell University Press, 1987
ISBN: 0801415179
$69
One of the most comprehensive books on diseases of trees and shrubs.

Insects That Feed on Trees and Shrubs
Warren T. Johnson and Howard H. Lyon
Cornell University Press, 1991
ISBN: 0801426022
$69
One of the most comprehensive book on insects and mites of trees and shrubs.

Diseases of Woody Ornamentals and Trees in Nurseries
Ronald K. Jones and D. Michael Benson
American Phytopathological Society, 2001
ISBN: 0890542643
$89
An excellent book on diseases of woody ornamentals and trees in nurseries.

Diseases and Pests of Ornamental Plants
Pascal P. Pirone
John Wiley & Sons, 5th Edition, 1978
ISBN: 0471072494
$110
A quick reference of common diseases and pests of ornamental plants.

Westcott's Plant Disease Handbook
R. Kenneth Horst
Chapman & Hall Publishing, 5th Edition, 1990
ISBN 0-412-06721-8
Out-of Print. Price varies for a used book.
Offers professionals and home gardeners diagnostic and disease-control information.

Plant Maintenance

Landscape Tree Factsheets: Including Evergreens, 2002
This is a revision of the *Street Tree Factsheets* published in 1993.
Henry D. Gerhold, Norman L. Lacasse, and Willet N. Wandell, Editors
Penn State University Publications Office, 2002; 814-865-6713 or 877-345-0691
ISBN 1-883956-00-5
$30
Technical advice on selecting and planting street trees; includes a comprehensive listing of recommended trees and their characteristics.

Plant Health Care for Woody Ornamentals
John Lloyd, Editor
University of Illinois, 1997
ISBN 1-883097-17-7
$45
A guide to ecologically sensitive maintenance and management techniques to maintain plants in the environment.

Pirone's Tree Maintenance
John R. Hartman, Thomas P. Pirone, and Mary Ann Sall
Oxford University Press, 7th Edition, 2000
ISBN 0-19-511991-6
$52
A guide for anyone interested in the maintenance and care of trees.

Well-Tended Perennial Garden: Planting and Pruning Techniques
Tracy Disabato-Aust
Timber Press, 1998
ISBN: 0881924148
$29
Excellent book on the maintenance of perennial gardens.

Turf Insects

Destructive Turf Insects
Harry D. Niemczyk and David J. Shetlar
G. I. E. Media, Incorporated, 2001
ISBN: 1883751144
$49
An excellent reference on identification and management of turf insects.

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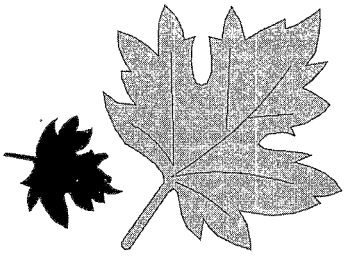
The Maples of Secrest Arboretum

Gary W. Graham, James A. Chatfield, and Kenneth D. Cochran

"I drove to Westernbirt, the arboretum in Gloustershire, one misty morning in October, 1994. The parkland was full of parked cars. 'Is there a pop concert or car rally?' I asked with dismay, 'No. They've come like you — to see the maples.'"

— Thomas Parkenham, from Meetings with Remarkable Trees



As at Westonbirt in England, we invite you to come see the maples at Secrest Arboretum at The Ohio State University's Ohio Agricultural Research and Development Center campus in Wooster, Ohio. Make a trek through the entire Arboretum, of course, but pay special attention this spring and in the future to the Secrest Maple Trail, and ask for a copy of the brochure for this self-guided trail.

Maples are in the genus *Acer* in the Aceraceae family, which includes only the genera *Acer* (with up to 200 species) and the rarely planted Chinese native *Dipteronia* (two species). All members of the Aceraceae are woody. Both genera are characterized by two-winged dry fruits known as samaras and leaves with opposite arrangement on the stem. All maples are native to the Northern Hemisphere, except for one species in the mountains of Java. Most maples have simple leaves, with the exception of several trifoliate species and box elder (*Acer negundo*). Many, but not all, maples have palm-like leaves, but some, such as *Acer carpinifolium*, noticeably do not.

Maples are widely used both for their wood and other plant products and as ornamental plants. The wood has long been used by man, as suggested by Virgil's account in the *Aeneid*, in which maple is described as being one of the woods used in the Trojan Horse. Today it is used widely in floors and walls of buildings, in bowling alleys and gymnasium floors, and as D. M. Gelderen *et al.* note in *Maples of the World*, the sycamore maple (*Acer pseudoplatanus*) "provides the most famous and distinguished use of maple wood — the back, sidewalls, and pegs of violins."

Gary W. Graham, Ohio State University Extension, Northeast District; James A. Chatfield, Ohio State University Extension, Northeast District and Department of Horticulture and Crop Science; Kenneth D. Cochran, Secrest Arboretum of The Ohio State University Ohio Agricultural Research and Development Center, Wooster, Ohio.

We all know of the wondrous qualities of maple sap from sugar maple (*Acer saccharum*) as the source of maple syrup, and several maples are amongst the best-known sources of honey (hedge maple, *Acer campestre*, and sycamore maple).

As ornamental plants, maples provide much to landscapes, street tree plantings, and other sites. They have the structural features to be outstanding shade trees; they are among the most spectacular of all trees for their fall foliage; and on some maples, twig color, exfoliating bark, flowers, and fruits are quite ornamental.

Among the maples are a diverse group of plants tolerant of a wide range of soil moisture, soil pH, and light tolerance. Sizes range from small shrub-like trees to towering giants, and shapes from pencil-like uprights to wide spreading shade trees.

At Secrest Arboretum on the campus of the Ohio Agricultural Research and Development Center, there is a diverse collection of maples. The Arboretum and OARDC have long been involved in maple evaluations in the internationally renowned Shade Tree Evaluation Plot and in other Arboretum plantings, as well as Howard Kribel's forestry research plots of "Super-Sweet" sugar maples.

Let's take a tour of the maples of Secrest Arboretum, starting with a few of the maples found at Secrest which are described here.

Acer buergerianum. Trident Maple.

This small (20 to 30 foot) native Chinese maple is one of the mainstays of bonsai horticulturists. The species has three-lobed leaves, variable red to purple fall coloration, and a preference for acid soils and full sun. It is an excellent patio tree and may be a good choice for landscape planters.

The most prominent specimen in the Arboretum is *Acer buergerianum* ssp. *formosanum* 'Naruto,' which is an unusual curled-leaved cultivar. It seems at first simply an oddity and a not-so-pleasing oddity at that, but the dark glossy leaves with dissected lobes become more and more attractive with maturity and familiarity. It grows on you!

It is great for plant diagnostic teasers, since the curled leaves seem suggestive of curling due to drought injury, growth-regulator herbicide injury, or aphid infestations. This specimen was given to the arboretum by Lake County nurseryman Tim Brotzman eight year ago, and, though some information is suggestive of hardiness issues, it has thrived in that time, including a transplanting to a sunnier site and will be propagated and trialed at other arboretum sites.

This specimen is found to the north of the Azalea Allee near the deciduous azaleas, just at the top of the hill.

Acer campestre. Hedge maple.

Hedge maple is a small to medium-sized native European maple (25 to 35 feet) which is widely used for hedges in Europe, including at Schonbrunn Castle in Vienna. It is also grown as a multi-stemmed shrub and as a small landscape tree.

Foliage features glossy, non-toothed, almost waxy three- to five-lobed palmate leaves. Petioles exude a milky sap when broken, similar to Norway maple. Samaras are almost horizontal. The tree is very adaptable as a street tree and can tolerate high pH or low pH, acid soils, sunny sites or partial shade, dry conditions as well as moist soils.

Acer campestre sometimes develops winged ridges on young stems. 'Queen Elizabeth' is a popular cultivar; we did see some drought stress in the tough summer of 2002.

At Secrest, hedge maples are in the Deciduous Tree Plot at OARDC, outside the Research Services Building, and two trees unusually plagued by leafhoppers on the OARDC campus are in front of Williams Hall. Additionally, there are many hedge maple volunteers that have sprouted from seeds spread in mulch.

Acer x *freemanii*. Freeman maple.

These intermediate to large-sized maples are hybrids of *Acer rubrum* (red maple) and *A. saccharinum* (silver maple), with intermediate characteristics of the two species, including faster growth and more dissected leaves than red maples and better branch structure and better fall color than silver maples.

The first documented hybrid was developed by Oliver Freeman, a plant breeder at the National Arboretum, but many Freeman maples in the trade are often due to unintentional hybridization and subsequent selection and cloning.

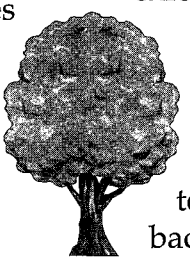
One prominent Freeman maple at Secrest is *A.* x *freemanii* 'Autumn Blaze,' selected by Glen Jeffers of Fostoria, Ohio, in the 1960s. Specimens of this hybrid were soon planted in the Arboretum and display an upright form, fast growth, and outstanding brilliant blazing orange-red to red fall color. After 35 years in the Arboretum, there has been no branch breakage.

Other Freeman maples at Secrest include the cultivars 'Celzam" (trademarked as 'Celebration' by Lake County Nursery in Ohio), 'Armstrong,' and Scarlet Sentinel.'

Freeman maples are found in the Deciduous Tree Plot at Secrest, and there is a planting of eight uniform 'Autumn Blaze' specimens along Ferguson Drive, opposite the Food Animal Health Research Building.

Acer griseum. Paperbark maple.

The paperbark maple is a small tree (20 to 30 feet) with attractive foliage, an oval to rounded growth habit, and spectacular stem and bark features. Leaves are trifoliate with bluish-green color on the upper surface and soft, downy hairs on the undersurface. The stems develop a cinnamon to orange-red color when young and seem to get better and better with age as the bark begins to exfoliate.



Since propagation is by seed, there can be considerable variation in stem and bark features. There is nothing quite like a paperbark maple on a winter day — with snow on the branches backed by a sunny blue sky with white puffy clouds.

This tree is reasonably adaptable to soil conditions and full sun or partial shade exposures. It is slow growing and sometimes develops some branch dieback if it is under- watered in establishment years, but once it grows out of awkwardness, the tree develops a graceful habit and is tolerant of dry sites.

At Secrest, the paperbark maples are in a shaded area in the maple grove, ascending the upgrade on Green Drive, and in the Deciduous Tree plot.

Acer pensylvanicum. Striped maple.

This small maple, sometimes known as moosewood, (15 to 25 feet and sometimes to 30 to 35 feet) is common in the Laurel Highlands of Pennsylvania, the Appalachians, and in the woods of New England. It thrives at Secrest and elsewhere as an understory species on well-drained soils, protected from sunny and hot, urban exposures.

The prime landscape feature is the elegant creamy white-striped bark on the reddish

and greenish young stems (this striping eventually fades on the bark with maturity). Leaves are five inches or more and three-lobed. The hanging clusters of greenish-yellow flowers and tiny samaras are attractive, though often overlooked. Fall color is yellow. In landscapes, striped maples are often multistemmed.

At Secrest, *A. pensylvanicum*, the hybrid *Acer* x 'White Tigress' introduced by nurseryman Tim Brotzman of Lake County, Ohio, and specimens of the Asian Manchustriped maple, *A. tegmentosum*, are all along the upper trail of the John Ford Azalea Allee.

A. pensylvanicum is the only so-called "snakebark" maple native to North America; there are over a dozen snakebark species of Asiatic origin. The "misspelling" of the *A. **pensylvanicum*** specific epithet is enshrined forever by the International Code of Botanical Nomenclature, courtesy of Linnaeus's original citation.

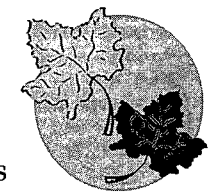
Acer pseudosieboldianum. Korean maple.

This small Asian maple native to Korea and Manchuria (up to 25 feet at maturity, wider than tall when small) is quite graceful, starting with bluish-green spring foliage with a soft appearance and touch due to tiny hairs which become less prominent as the season progresses. Small two-inch leaves have nine or more lobes, which taper to sharp points and have serration on the upper portion of the lobes.

Fall color is an outstanding ornamental feature with an ever more spectacular mix of bright yellows, oranges, and reds as the season progresses. Korean maple is one of the best small maples for overall structure and is hardier than many Japanese maples *(A. palmatum).*

At Secrest, *A. pseudosieboldianum* can be found near the Azalea Allee in the mixed planting and in the maple collection across from the Deciduous Tree Evaluation plot.

Acer rubrum. Red Maple.



Also known as swamp maple, this is a widely successful native maple in eastern U.S. forests and in many types of landscapes. Tolerant of wet sites, it is vulnerable to problems in dry and windswept sites and develops manganese deficiency in alkaline soils. *A. rubrum* is a fairly large maple, often 40 to 60 feet tall with age, and can grow much taller. Leaves are three to five lobed but mostly with three major lobes with much less dissection than silver maple.

Vibrant red flowers (especially pistillate types) with small petals are striking in March and April on the then leafless trees. Samaras develop and fall early, and this early maturity is an advantage in woodlands compared to species with fall seed maturity.

Variable fall color is reliably brilliant in widely planted selections such as 'Red Sunset.'™ Secrest's Deciduous Tree Evaluation Plot was an early proving ground for the J. Frank Schmidt's Nursery-trademarked 'Red Sunset'™ ('Franksred' is the cultivar), and Princeton Nursery introduced 'October Glory.' For fall color and winter hardiness, Red Sunset™ is hard to beat.

'October Glory' is one of the latest for fall color, and in 2002, it peaked only about 10 days before Thanksgiving. Check out these cultivars and 'Columnare' and 'Schlesingeri' in the Deciduous Tree Evaluation Plot at Secrest. When nurserymen visit the Deciduous Tree plot, they often comment positively on 'Columnare' for its tolerance of droughty years, its oval columnar shape, its dark green summer foliage color, and its resistance to leafhoppers.

Acer rufinerve. Redvein maple.

This is a small (20 to 25 foot) Asian snakebark maple with good yellow to orange-red fall color, lustrous green young stems with defined white striations, and prominent red spatulate bud scales that make for a great plant ID feature.

Leaves are triangular in shape with the center lobe longer and about four to six inches long and as wide. The upper leaf surface is deep green, but the lower is much lighter and with a reddish pubescence along the veins, as suggested by its common name. This tree is tolerant of most soils and is typically grown in partial shade.

Look for redvein maple in the mixed maple grove near the southern terminus of Green Road in the Arboretum. There are two nice specimens along the John Ford Azalea Allee.

Acer saccharum. Sugar maple.

There are a number of sugar maple types at Secrest Arboretum, ranging from the "Super-Sweet" test plots in the old eastern portion of the Arboretum that is cut off from the main plantings by Route 250 to the naturally growing sugar maples that lend their golden fall color to the undeveloped woodlands.

There are several unusual clones that illustrate the range of this species. 'Sweet Shadow' is a cultivar with deeply cut leaves, with each lobe cut as well. It has excellent orange-yellow fall color. There are fine specimens in the Deciduous Tree plot.

'Temple's Upright' is an incredibly narrow spire-like form that always attracts attention, and when the plot was thinned, 'Temple's Upright' was never considered for removal due to this interest — and the fact that it takes up so little horizontal space!

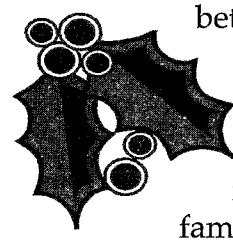
'Kompact' is a wonderful broadly pyramidal form which looks sheared but is not and has excellent orangish-yellow fall foliage color.

So, come to Secrest — to see the maples!

~ 25 ~
Deck the Halls with Boughs from Ollie!

Kenneth D. Cochran and James A. Chatfield

Dr. Oliver D. (Ollie) Diller, a renowned professional forester and avid holly fancier lived in a charming, heavily wooded hideaway estate on Wayne Avenue in Wooster, Ohio. Ollie also was once chair of the Ohio State University's Ohio Agricultural Research and Development Center (OARDC) Department of Forestry and the second curator of Secrest Arboretum, following the tenure of Edmund Secrest himself.



At his home, Ollie developed and maintained a private arboretum including many unusual trees and shrubs and many hollies. His enchanting estate included a small barn where he annually bagged hundreds of berry-laden holly sprigs to give to convalescent homes, local nurses, and his list of friends. Each Christmas folks looked forward to a bag of "Ollie's Hollies."

Ollie's gracious livelihood in growing and giving hollies not only contributed much toward the promotion of holly (genus *Ilex)* but also helped to extol its virtues to many friends and neighbors. The joy of sharing plant material with friends is rewarding!

So as we study the *Ilex* of Secrest, let us remember the work of Ollie Diller and his colleague, John Ford, who started this collection at OARDC's Secrest Arboretum in 1965 so that we might all have hardier and better cultivars!

Avid gardeners enthusiastically grow and use hollies in garden making, but for many consumers, the growing and use of hollies in Ohio is unfamiliar. The information presented here should be helpful to new holly growers and old holly hands alike.

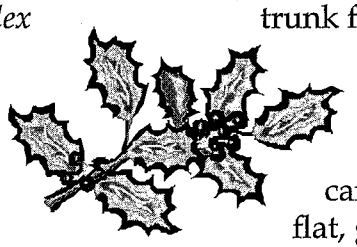
Evergreen and Deciduous Hollies

For practical purposes, evergreens are defined as coniferous (cone bearing) or broadleaved; examples of the former are hemlock, arborvitae, juniper, and pine and examples of the latter are rhododendron, azalea, and holly. Not all hollies are broadleaved evergreens, however; some are leafless in the dormant winter and are collectively called deciduous hollies.

To the average reader, "holly" conjures up a picture of a shiny-leaved plant with bright red fruit. However, holly enthusiasts know that these spiny-shiny hollies are not the only taxa in the nearly 700 species of the genus *Ilex,* family Aquifoliaceae. Plants in the holly family are dioecious; male and female flowers are on separate plants.

Kenneth D. Cochran, Secrest Arboretum of The Ohio State University Ohio Agricultural Research and Development Center, Wooster, Ohio; and James A. Chatfield, Ohio State University Extension, Northeast District and Department of Horticulture and Crop Science.

Most hollies are a welcome sight in the winter landscape or as sprigs of "specialty cuts" for interior decoration. Whether it is the luxuriance of their evergreen foliage against contrasting colored fruit, the potential for placing potted specimens on a cool solarium, or the brightly colored fruit on leafless branches of the deciduous holly, *Ilex* helps brighten the winter months.



Hollies to plant in USDA Cold Hardiness Zone 5b at Secrest Arboretum include: *Ilex opaca,* American holly; *Ilex crenata,* Japanese holly; *Ilex pedunculosa,* longstalk holly; *Ilex verticillata,* Michigan winterberry; *Ilex x meserveae,* Meserve holly; *Ilex glabra,* inkberry holly and *Ilex serrata,* Japanese winterberry.

Landscaping with Hollies

The sophisticated gardener ranks holly high in landscape value. The early colonists gave holly a prominent place because of its beauty and background. What has been done with hollies and with gardens in the past greatly influences landscapes for present-day living.

Formality and exactness in design demand that hollies be placed in relationship to patterns of the garden, generally balanced with walks, walls, gates, borders, and other construction amenities. Naturalizing plants in the landscape tends to scatter hollies in no particular pattern throughout large planting beds.

With the development of many new plants and especially select cultivars of various species — not only hollies — there is a great and varied palette of plants to use in the landscape. Present-day landscapers value the image and prestige of using hollies in two or more of these relationships.

Many tree-form hollies make splendid specimens with foliage full from the ground to the top of the plant. The size and branch structure will vary in holly trees, however, and as an alternative to a low-branched tree, one may desire to remove the lower limbs to expose the trunk or to show an interesting trunk formation.

Holly trees are also fine material for background, screen planting, and foundation planting. They can be sheared to form an almost flat, green wall, selectively pruned to form a looser dense wall, or not pruned and left to grow to maturity.

Shrub-type hollies mature to various sizes and forms, showing their texture and color compatibility with various building materials and architectural styles. Shrubs can be used as an individual specimen, in a step-down border planting, as edging for beds, or massed in a foundation planting with three, five, or seven plants of a kind.

An emphasis should be given to selecting shrubs for landscape relationships of plant size and form, and for ornamental qualities and hardscape elements, all coupled into one or more environments. The dwarf cultivars have potential for bordering terraces and patios, courtyards and entry gardens, and in small gardens.

Cold Hardiness of Holly

North, South, East, or West, in all except a few states, holly can be grown. Even a Northerner can grow hollies with certain species and cultivars surviving in habitats or under environmental extremes and stresses of moisture and temperature. Broadleaved evergreen hollies growing in cold winter climates are positioned for optimal growth and development if planted in a microclimate. Strong drying winds, coupled with temperatures below zero degrees Fahrenheit

and a lack of snow cover, cause more rapid desiccation of leaves in open locations than in microclimates.

There is probably as much damage from desiccation as there is from freezing. Plants exposed to winter sun, plants deprived of nutrients, and even plants with unprecedented heavy fruit set previous to a cold winter could accentuate the final winter injury. Until a plant has a deep root system, winter injury may result. The water loss in broadleaved evergreens from drying winter winds and the combination of deep frozen soil and a lack of mulch may result in massive top damage if not outright winter kill. This is especially true when a plant has a southern exposure.

Microclimates are uniform local climates of a small area or habitat that gives plants relief from the brightest and warmest portion of the day and from strong wind-swept exposures that tend to increase foliage desiccation and thus produce stress conditions for the plant. The east side of a building or an east-facing shelter of plants is an ideal microclimate for hollies, particularly if it receives sun before the heat of the day.

Try the plant — even if it is marginally cold hardy — and be willing to take a chance. Take the time to maximize cultural care and enjoy it as long as it lasts. And if it dies, try it again, in fact, give it three tries before it's out!

Remember the words of Peter Smithers, who said: "I consider every plant hardy until I have killed it myself."

Growing Hollies

As a rule of thumb, the preferred habitat for most evergreen hollies is a slightly acid, well-drained soil, rather light with incorporated humus and a copious water supply. After a good watering, do not water again until the soil at the drip line of the plant and two inches below the surface will not hold a form when squeezed in the hand. The soil should always be in this condition except after watering or after a rain.

As with all new plantings, the first three years of horticultural care after planting are crucial. Fertilize in late February or early March. Preferably transplant in spring just before new growth commences or in late summer after new growth has hardened.

Late autumn transplanted broadleaved evergreens are generally hard hit by winter conditions. Do not hesitate to prune hollies. They may be sheared or pruned heavily without ill effects.

Cultivar Selection

Among the distinct advantages of one cultivar over another are the following:

- Growth habit ranges from low and spreading shrubs to upright trees.
- Leaf size ranges from one inch to five inches.
- Fruit color includes red, yellow, orange, carmine, black, and even white.
- Holly foliage features vary from very fine to very course textures and modifying from very beautiful dark greens to grays and variegations.

Many cultivars also have the distinction of having spines and beautifully shaped leaves — some smooth, some crinkly, some cupped, and some with many other interesting shapes. The berries not only give us pleasure, but they provide food for birds when other fruits have disappeared.

Certain species and hybrid cultivars are strongly emphasized for specific geographical areas, and certain cultivars are disadvantaged in some geographic regions. Many of the cultivars of holly species that have been introduced are representative selections from a limited portion of their natural range.

Pollination

Most hollies are dioecious; therefore, to assure a fruit crop, plant the pistillate parent (female) and staminate parent (male) plants in proximity. The male plant does not have to be planted too close — within a few hundred feet of the female cultivars is preferred, although pollination has been known to take place when the male and female plants were as much as half a mile from each other.

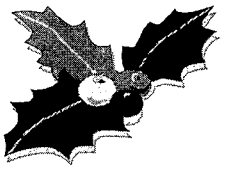
One male plant should pollinate eight to 25 females, provided it is the same species and has the same flowering period as that of the female cultivar. This is essential because the blooming periods of two taxa of holly vary somewhat. The males and pollinating insects do a wonderful job of working together. Regardless of the right pollination conditions, the quantity, size, and retention of fruit produced may vary from year to year, depending on the weather conditions.

Authors' Choices

Our choices do not necessarily mean that these hollies will be the best for your landscape situation because some hollies grow and develop in some geographic regions better than others. In the Midwest, some evergreen hollies may not do well, particularly in reference to cold hardiness.

For Wooster, Ohio, these choices have proved true and appear to be the best of the hollies. Brief descriptions of these choices are presented here.

Ilex opaca (American holly)



Ilex opaca, a native species to eastern and southeastern United States, will grow in zones where cold winters are possible. It has been reported that severe cold winters, such as 1976-77 (one of the coldest on record), 1977-1978, and 1984-85, did not adversely affect many selections of American holly in states such as Connecticut and Ohio. These plants may lose all of their leaves in a particular winter, but with few exceptions, they recover fully the following spring season with no apparent damage to the wood.

Ilex opaca **'Canary'** and *Ilex opaca* **'Morgan Gold'** are tops on the list for vivid yellow (not gold or orange) fruiting American holly. Both are dense, broadly pyramidal to oval, medium-sized trees maturing to about 35 feet in height. Foliage is glossy olive green. The authors really like the design effect of the curved leaf blade of 'Canary.'

Ilex opaca **'Bountiful,'** *Ilex opaca* **'Cumberland,'** and *Ilex opaca* **'Marta'** are vivid red-fruiting American hollies (not orange-red or blood red, but vivid red). The foliage is glossy olive to dark green.

Ilex opaca **'Makepeace,'** and *Ilex opaca* **'Milford'** are both male selections, with glossy, olive green foliage.

These selections of American holly cultivars are based on foliage color and sheen, and those cultivars that are less susceptible to holly leaf minor.

Ilex glabra (Inkberry holly)

The species, *Ilex glabra,* has an entire leaf margin (no spines) and black fruit. The species generally retains good winter foliage and is reported to grow in Zone 4. The authors like it because it adapts to our climate and soils. In the wild, it is found in swamps where it forms beautiful evergreen colonies

with loose branches waving in the breeze. If only it was not susceptible to leaf miner! Alas, one of the key natural predators of holly leaf miner does not survive in our climate.

***Ilex glabra* f. *leucocarpa* 'Ivory Queen'** is the only ivory-fruited *Ilex*. The evergreen foliage is dark green, the branching is loose; and this medium-sized shrub matures to a rounded form. We like it in a brightly lighted microclimate or massed in a low valley.

Ilex pedunculosa (Longstalk holly).

Ilex pedunculosa is still little known in the nursery trade. It is a large shrub or small tree with bright evergreen touch-friendly foliage, with entire leaf margin and without spines. Pea-sized cherry-red fruit hang from the end of comparatively long stalks, thus the common name longstalk holly.

Certain specimens have suffered from significant branch dieback (*Phytophthora)* in Secrest Arboretum, but seedling progeny vary greatly in susceptibility as well as in leaf and fruit size and plant form. Following an inspiration from the late nurseryman Tony Shamarello of Euclid, we are working at Secrest on developing tree forms of this holly. The species origin is Japan, China, and Taiwan.

Meserve Hybrid Hollies

Ilex x *meserveae* 'Blue Princess' and 'Blue Prince' are a pair of dependable hollies maturing as small- to medium-sized shrubs. *Ilex x meserveae* is the grex name for all hybrids obtained as a result of crossing plants of the two species *Ilex aquifolium* x *Ilex rugosa.*

The popular name "blue hollies" has been applied to some of the Meserve hybrids because their foliage and stems develop an attractive, dark bluish-green pigmentation. The leaves are not sharply spiny, and they have a striking sheen to the foliage. We have never met a blue holly we didn't like and, as a design element, think it fits anywhere, especially peeking out amongst other broadleaf plants. Most cultivars of this hybrid are susceptible to summer droughts, and supplemental irrigation during these periods is advisable.

Ilex verticillata (Michigan winterberry)

***Ilex verticillata* 'Winter Red,' 'Winter Gold,'** and **'Red Sprite'** are deciduous holly selections of superior phenotypic expression for ornamental purposes and habitat preference. The name tells the fruit color, and they are abundantly produced along the stem, persisting through the winter in mild years. 'Winter Red' and 'Winter Gold' are multi-stemmed medium-sized shrubs, and 'Red Sprite' matures to a small- to medium-sized compact shrub.

Where evergreen hollies cannot be grown in colder parts of the country, winterberry holly plants appear to be of greater use as northern selections. They are relatively unaffected by sub-zero winter temperatures, but red berries will blacken under extreme cold. Lack of moisture during flowering affects pollination as with most hollies, and drought conditions during the heat of summer will bring wilt to established plants, and, if supplemental water is not applied, fruit will be smaller and fruit retention will be reduced. Plant in full sun.

The species is native to bog and swamp areas, and it is tolerant of lowland areas in the landscape, but it grows well in good garden soil. Avoid plants in high/dry sites. Due to differences in blooming time among the various selections, female cultivars should be matched with certain male cultivars in order to assure abundant fruit set.

Ilex crenata (Japanese holly)

Ilex crenata 'Pride's Tim' is a small spreading evergreen Japanese holly.

"I will always remember the time that I had four or five plants growing in a poor location and said, 'I'm going to either find a better location for these plants or else I am going to throw them away, since they are looking so poorly.' I found a microclimate on an east-facing slope and tucked them in around a Betty magnolia. That planting has made a beautiful three- to four-foot-high broad spreading groundcover. And this year I am going to propagate it, because I don't know where I can buy the selection, and I want to experiment with it further." (K. Cochran).

Have fun with your hollies and let us know of your growing experiences.

"Whosoever against Holly do sing,
He may weep and his handys wring."

— 15th Century Carol

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